A·READER·IN PHYSICAL GEOGRAPHY

R·E·DODGE

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FOR BEGINNERS

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BY

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PREFACE.

THIS little book has been written with the thought that hitherto no one volume has been available in which the more important principles of Physical Geography have been brought together in a form to be used by beginners in the subject. The demand for such a treatment of Physical Geography grows larger daily, and in attempting to meet that demand the author has aimed to adapt the subject-matter to the needs, the abilities, and the interests of youthful readers. For that reason much attention has been given to human and other life conditions, in so far as they are dependent upon, or determined by, the physical features of the world.

Although it is believed that the facts are accurate as stated, and the generalizations tenable, there has been no attempt to write a complete text-book in Physical Geography. The thought has been rather to write a suggestive book that would leave the reader with a desire to go further and find more. Partly for that reason, and partly to give training in seeking information in other sources, no attention has been given to summaries of the physical features of the several continents. It is hoped that the book may be used as a reader in association with a text-book, and that details in reference to special topics will be sought under the description of the continents in such text-books, and, further, that an atlas may constantly be used in connection with the book. Long-

mans' New School Atlas is recommended as being in many ways the most serviceable; but the maps accompanying our better school geographies will well serve the needed purpose.

The illustrations are very largely from original photographs by the author, and have been chosen for their geographical value rather than as mere pictures. As far as possible diagrams have been avoided. Certain courtesies in reference to the illustrations are noted in the text. The author has also received permission to use original photographs from many sources, and is especially indebted to several of his colleagues in the Teachers College. Thanks for assistance in reference to illustrations is also cordially given to the following: The United States Geological Survey, The Maryland Geological Survey, The New York Zoölogical Garden, The Hyde Exploring Expedition, Mr. J. B. Woodworth of Harvard University, Mr. G. H. Barton of the Massachusetts Institute of Technology, and Mr. J. T. McDonald of Delhi, New York.

Miss Caroline W. Hotchkiss and Miss Clara B. Kirchwey, instructors in the Horace Mann School of Teachers College, have offered many valuable suggestions in reference to the text, and Miss Mabel K. Myers has prepared the index and assisted with the proofs.

RICHARD E. DODGE.

OCTOBER, 1900.

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A READER IN PHYSICAL GEOGRAPHY.

CHAPTER I.

THE WORLD AS A WHOLE.

EVERY one knows something about geography, though he may not have learned it from books and atlases, and makes some use of his knowledge in every-day life. The city boy follows a certain route between school and home, because the city has been planned so that the main streets avoid the steep slopes, and because the school-house has been built where it would be easily reached by a large number of pupils. The country boy knows where to find the springs and the swimming pools in the brooks, and can tell you what sort of land is the best for certain crops. He makes his way across the country without paying attention to the roads, because he knows the geography of the whole region thoroughly, and perhaps could make a map of it with his eyes shut. He knows its geography from personal study of the land itself, and not from having read about it in books. The Indian of the great plains of the West follows the easiest and best route between one place and another across the so-called "trackless waste," because he knows the relative position of every peak and valley, and is as much accustomed to finding his way by seeking out certain

landmarks as the city boy is by noting the buildings and the familiar street corners.

No one who is interested in what is going on in the world can fail to be interested in geography, for it is only through his knowledge of the geography of a region that he can understand what men are doing there, and why they are living and acting in certain ways. Nearly every spring we read of destructive windstorms or tornadoes in some of our Central States, particularly in Missouri or Kansas. The storms are of special interest because of their violence and destructive nature, yet we cannot understand such storms unless we know something more about them than their location. We must know what causes such winds at certain seasons, and why these prairie States seem to be the regions where such storms are the worst. In such a little thing as this we have to study the conditions of the air that cause the winds, the character of the land over which the winds move, and the effects on men and all living things. We are here studying some of the forces of nature at work, but all the facts are geographical.

But it would be a mistake to suppose that geography is a study of the earth and of natural forces only. An important and interesting part of geography deals with the people of the earth, how they live, what they do for a living, and why they have chosen to dwell just where they do instead of elsewhere. Geography helps us to understand the people, as well as the places, climate, and natural features of the earth. We are sometimes amused at the customs of strange people who live in foreign lands, just as we may be at the queer ways of our neighbors, and forget that these other people are just as likely to think us queer as we are to think them queer, and that

they have the same right to be amused at us as we have to be amused at them. We would not be so amused did we realize that people living amid conditions different from those around us cannot live as we live. A farmer accustomed to take his time to reach home after his day's work might open his eyes in wonder at the way people in large cities rush and crowd to get seats on ferry-boats or on trains, and think them very foolish to waste so much energy. If he were to come away from the quiet of his farm and live in a city, he might soon be rushing about, seemingly as crazy as all his neighbors. In the same way we may think it curious that many Indians live in movable tents or tepees rather than in permanent houses; but we would soon find out, were we to try to live in the Indian country according to our civilized customs, that the Indian knows better than we how to be comfortable and healthy in his home on the plains. Such are a few of the features of the world that are readily understood as soon as we know the geography of the regions in which they occur.

The world is so large, and the facts to be known about it and its inhabitants are so many and varied, that it is not possible for us to study the whole field in detail. But geographical facts are, after all, very much alike the world over. And we shall find that if we study carefully our own home locality, we shall have, as it were, a key to the understanding of every other region. Our very coldest winter days help us to realize the kind of weather the Eskimo endures most of the time, and a hot, muggy day in summer, when we feel lazy and want to do nothing but try to keep cool, makes us understand why the black man of Central Africa is neither energetic nor enterprising. Again, we know by looking about us that

every part of the city or district in which we live is not equally desirable for homes, and that there are some places that are not occupied at all. This fact may help us to understand why it is that there are portions of the world where, either because the slopes are too steep or because the soil is barren, or for some like reason, no one cares to live, or, indeed, can live.

Thus by observing the geographical conditions close at hand we are prepared to appreciate those at a distance. If, however, we are to use these home conditions as keys or measures in this way, we must first come to know thoroughly our own surroundings. This does not mean that we must study our own town or city or State as a thing by itself, with no thought of its relation to the rest of the world, of which it is but a small part; for that would be much like thinking that one grape, taken by chance from a bunch, gave us the right idea of the whole bunch or of all the bunches on the vine. Before, therefore, we look at the small details of the geography about us, let us see some of the things there are in the world which affect us just as they affect all men the world over.

Our Relation to the World as a Whole.—The world as a whole is made up of land, water, and air; and of these the great bodies of land are the most important to us, for we live *on* and travel *over* the land, and get from it, either directly or indirectly, nearly all those materials that furnish us food, clothing, and shelter—the three things that we must have in order to live. It is true that there are places in the world where men may go beneath the surface of the earth a very slight distance, in mines or in railway tunnels; but their stay, as a usual thing, is very short. The longest railway tunnel can be passed through in a few minutes, and most miners have their

homes on the surface of the earth, though they may stay several hours a day underground. Hence we can truthfully say that the vast majority of men live on the very *surface* of the land, and have but little to do with any other part of it. Indeed, we may almost say that man has never descended into the earth * a distance far enough to be thought of as being below the surface at all, for the deepest mine only penetrates the earth about a mile, and it is about four thousand miles to the centre of the earth.

In the same way, we have but little to do with other than the surfaces of the rivers, lakes, and oceans of the world. We sail *over* the water of the oceans and large rivers and lakes with almost equal ease in any direction, and except in the case of deep-sea fishing, men are but little concerned in their daily life with any other parts of the waters of the world than the ever-moving and ever-changing surface.

When we think of the air, however, it is far different; for we live at the *bottom* of the atmosphere, and are related to it very much as a fish in the deep sea is related to the waters of the ocean. Occasionally men do rise into the air for a short distance in balloons, but they have not learned how to travel through the air or how to live in it, except at the bottom. The most hazardous voyages in balloons have carried men but little farther above the earth than mines go into it, and even birds that leave the solid earth, and remain poised above our heads for hours at a time, can reach but a limited height;

* The word *earth* is sometimes used to refer to the whole globe on which we live, and sometimes to the solid or rock part of that globe. It will be used in the latter sense here, and *world* will be used when we refer to the whole globe.

they, like people and animals who stay on the ground, are really at the bottom of the great ocean of air that stretches above the world for an unknown distance.

Beneath the oceans, as well as beneath the continents, are the solid rocks of the earth, that form the central core of the world—the foundation on which all else rests. This arrangement is just what we would expect; for the solid earth is at the bottom, the liquid water is next above, and the invisible, gaseous atmosphere is over all, the three great parts of the world being thus arranged in the order of their weight. Yet these three divisions of the world are not absolutely separated, for the rocks and soils of the surface of the earth contain a great quantity of water, which, creeping along underground, feeds the roots of plants. Whenever this water appears at the surface, we have a wet place or a spring, from which water may trickle in a small stream. Every such spring or wet place is one of the beginnings of a large river; but it takes many, indeed hundreds of thousands, of such small springs to make a large river such as the Mississippi.

It is not, however, near the surface of the earth alone that water occurs in the rocks. Indeed, the deeper we go into the earth, the more water there seems to be, as any miner can tell you; for in some cases the water runs into the mines so fast that large pumps have to be used night and day to keep the mine from filling. The holes and cracks in the rocks of the earth that are not full of water are full of air, so that we may say that on the land the earth, air, and water are thoroughly mingled.

In the same way we find a mingling of air and earth in the waters of the oceans, rivers, and lakes. The rock material in the water is easily seen, for most rivers, particularly after a rain, are much discolored from the mud

they contain. Indeed, the cleanest rain water of the heaviest storm contains rock material dissolved, as sugar may be dissolved in water that seems clear, and there is no water absolutely free from rock impurities except that which has been artificially purified in some chemical laboratory or large factory.

Passing from the water and earth to the air, we find again a mingling of materials similar to that we have seen before. The air contains a great deal of water, which is at times invisible, but at other times perfectly visible as mist or fog. During storms some of this water or moisture falls to the earth, and runs down the slopes, making rivers that flow toward the oceans. Even after a heavy storm lasting several days, there is still a large amount of moisture left in the air, varying with the day and the part of the world. The air may be clear, apparently; but anything that absorbs moisture easily, like the wool on the back of a sheep, will feel damp to the touch, showing that moisture is present. The air in the eastern United States is most free from moisture during a clear, cold snap in winter, when the stars twinkle, and everything seems to crackle with dryness.

The particles of rock dust of a windy March day, and the dancing rays of the sunbeams as they stream across a room in a narrow path, tell us that there is rock material as well as moisture in the air. It is the dust in the air which catches the rays of light at sunset and gives us much of the beautiful color that we associate with that hour of the day. Thus we see that the three great divisions of the world we have mentioned are anything but independent and separate ; indeed, the mingling is so complete that it is hard to deal with one of the three divisions without considering the others at the same time.

For most of us, however, the surface of the earth is our home; the oceans are the great wastes that separate the continents and many of the greater nations, but at the same time they are the great highways of commerce and travel that bind distant peoples more closely together; the air gives us breath and power to do work; and the three parts working together make living possible. Yet, since the earth is the home of man, it is the earth that we shall study here in the most detail, making as much use of the facts of air and water as is necessary in order to understand the story of man's history and activity in the different parts of the world.

It would be a long and tiresome task, however, to try to study the whole world with equal care. Indeed, such a study would be impossible, for there are many parts of the world concerning which so little is known that a detailed consideration is out of the question. As we cannot spend all our lives studying even those parts that are the best known and the most important, we must save time in some way if we are to get any satisfaction from our study. The best way to save time is to study in detail, as has been suggested, some few regions which we can use as guides to the study of other regions. For instance, if the study of New York State shows us that the great railroads follow river valleys, we can express that fact in a simple way that will be useful afterwards, and it will not be necessary to study every railroad in the world with equal care, for we should be safe in saying that, as a rule, railroads follow river valleys. If we found a case where this did not hold true, then we should have an exception to the rule, which we could study with special care.

As we cannot, however, personally see all the many

parts of the land surface of the world, we must get our facts largely from the written descriptions, the pictures, the stories, and the maps that have been given us by travellers who have seen that which they describe. No one book can tell us all that is known concerning the world, and small school geographies, which must contain something about all the important parts of the world, cannot be very full and satisfying in reference to any one region, even our own country. The word of a traveller is more interesting than that of a text-book, because the traveller has seen what he describes, while the writer of the book is only quoting, perhaps, the words of others. A map, however, tells more in a small space than any other form of description, because a few symbols like those used to represent mountains or rivers stand for many details. The map cannot picture to us all the beauties of the mountains, or the details of the river valleys; but we can see at a glance their position and relation, when it might take us hours to get the same idea from reading. Even then we should probably need to make a map to see the relation clearly, just as a stranger can better understand our directions for finding a certain place in a large city if we show him the location of the streets by a little drawing.

THE CONTINENTS.

CHAPTER II.

THE LARGER FEATURES OF THE CONTINENTS.

Continents and Oceans.—As we are thus most interested in the land and water areas of the world, let us look for a moment at some of the most striking things that a good map tells us about these areas. A large wall map, large enough to be readily studied from across the room, will suit our purpose; but a good globe is better, as it expresses to us the shape of the continents and oceans of the world, as well as the direction of one area from another. Such a map or globe shows us readily that the land is distributed over the world in masses of several sizes, the largest and most continuous known as continents, and the smaller and more separated called islands. The lowest parts of the earth between the continents are full of salt water up to a certain level which we know as the "sea level"; indeed, the hollows are so full that the waters surround the continents, in some cases spilling over the brim, as in Bering Strait, between Asia and North America.

Though continuous, the great salt-water area of the world is commonly divided into the large oceans, like the Atlantic or Indian, and the smaller seas, like the Caribbean. In some cases, however, that which we would

expect to call a sea is known as a gulf, like the Gulf of Mexico, or a bay, like Hudson Bay, so that *gulf*, *bay*, and *sea* may be used almost interchangeably, though sea is the most common and the best name.

If, now, we look at the globe from a greater distance, as from across the room, we cannot help noticing that nearly all of the land is arranged about the North Pole as a centre. If we look directly down on London, England, the half of the globe which we see contains nearly all of the land; though the water occupies more than three-fourths of the globe, the greater part is in the other half of the world from that just noted. This long-distance view tells us at once that the greater areas on which men, animals, and plants can live are in the northern half of the world, or our hemisphere. We should therefore expect the northern hemisphere to contain, as it does, the largest and most powerful nations of the world, and to be the most important for study.

Coast Line. Harbors.—As our eye passes from the land to the water or the water to the land, we cannot help noting the line where they meet, which we call the coast line or the seashore. The landsman who makes an occasional trip to the distant ocean speaks of his journey to the *seashore* or perhaps to the *beach;* but the sailor, driven in a storm before the waves and wind toward an unfriendly and dangerous land, dreads the *coast*, for it is the coast more than the water that he then fears.

The coast line of a continent, however, deserves mention for other reasons than because it shows the edge of the land, the inner margin of the sea. If a country is to have a profitable foreign commerce, it must be well provided with good harbors. A country with a regular, unbroken shore, such as that of New Jersey and our

Southern Atlantic States, or that of Africa and western France, has but few inlets. Such a country offers vessels no chance to find protected anchorage in time of storm, and no good landings for loading or unloading, and hence cannot have many large commercial cities along its coast. Such dangerous coasts are usually provided with life-saving stations, where men are continually on the watch to offer assistance in case of a wreck. (See Fig. 1.)

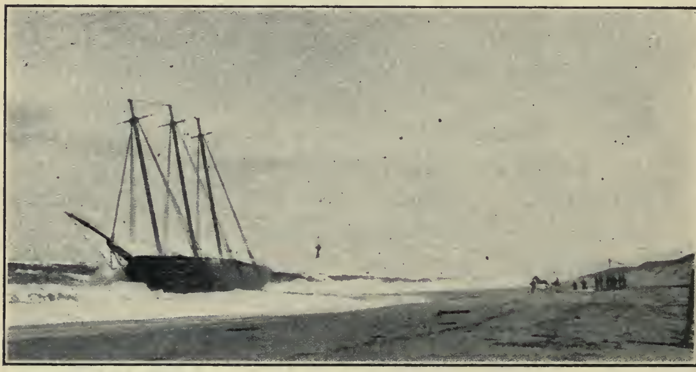

FIG. 1.—A REGULAR SHORE AT PROVINCETOWN, MASSACHUSETTS, SHOWING LIFE-SAVING CREW RESCUING A MAN FROM A WRECK.

On the other hand, those countries that have a much cut-up, a very irregular shore line, offer unusual opportunities for commerce by sea. As examples of such irregular or embayed shore lines, study the eastern coast of the United States from New York northward, the northern shore of the Mediterranean, and the coast of England, and note how they are lined with good harbors and commercial cities. Of course, good harbors are not all-important, for there cannot be trade and commerce unless a country has something to sell, and a

country that can get its goods to market with the least cost and delay will have a great advantage over any rival region. This suggests another reason why an irregular shore line is important, for the bays, running far into the land, give vessels a chance to sail nearer to the heart of the country, thus allowing goods to be shipped to foreign ports or to other coast ports without long journeys by railroad or canal. Hence a country with bays and promontories is in several ways better fitted for trade than a country whose shore line is formed of bold bluffs or stretches of sandy beaches, perhaps miles in length.

The coast line is thus, we might say, the key to the question of whether a country will be powerful and rich or not. Of two countries with conditions in each equally favorable for producing riches, and with equal ability among the people to take advantage of their surroundings, that country with an irregular coast ought to be the more prosperous.

Back of the coast, however, is the land, and it is only the careful study of the land that will tell us whether the conditions are favorable for producing the commodities men must have before they can trade for those things which they need or desire.

The Land.—Having now had a glimpse of the larger features of the continents and oceans, let us look carefully at the more important facts in reference to the land, beginning, perhaps, with our own continent. To get a good idea of such an extensive area, we need a larger representation than the small patch shown on a globe. We need a large wall map, and preferably a map that shows, among other things, at least the positions of the principal cities and towns, the larger rivers, the bounda-

ries of countries, and further, one that indicates roughly, by different shades of color, the height, or *altitude*, of the country above the level of the sea. That is, we ought to be able from the map to tell where the highlands and lowlands of a country lie.

From a map representing so large an area, and of ordinary size, we can gain, of course, no real picture of the actual aspect of a country, its ups and downs, its slopes, its valleys and streams; but we can learn whether the region studied should be called mountainous or hilly; and if it be high and rugged, we can see how broad the mountain mass is, and in what direction it extends. If the region be low and flat, we know it to be a plain; if it be high and more or less level, we would commonly call it a plateau.

Highlands and Lowlands.—Having thus located the lowlands and highlands of a region, and found out in a rough way where people can live with greatest ease and success, we are ready to study the rivers that flow from highlands to lowlands, and finding out whether they are large or small, long or short, swift or gentle, we shall be able to tell whether they give means of commerce or furnish sufficient water for factories or farms. If we add to these facts some knowledge of the climate, we have gained a good idea as to whether the country as a whole is habitable or not. Highlands with few rivers, and those inaccessible because of steep slopes, we would naturally expect to be forested, to be the home of wild animals, and perhaps of scattered shepherds and herdsmen, if men could live there at all. On such highland masses we would expect strong and probably cold winds, with much snow in the winter, and a short, warm summer. It would be a favorable place, if conveniently located,

for summer hotels, but in most ways unfavorable for man the year round.

We would expect that railways and carriage ways across the mountain ranges would be few and far apart, and that the cost of building and keeping good roads in repair would be very great. It would be difficult for people on one side of such high mountains to see much of their neighbors on the other side. The Highlands of Scotland, for instance, have many deep, narrow valleys called glens. Those who live in the same glen have grown to have similar customs, and to be, as we say, clannish, distrustful, and perhaps jealous of the members of other clans.

We can tell, then, from such a map study the direction and character of the streams which naturally flow from highlands to lowlands, and, in a general way, can prophesy where people will live, what they will do, and what will be their relations with their neighbors. Such prophesying is interesting, as the working out of a puzzle is interesting, because it presents problems for us to work out, something to do that is worth doing, and that is agreeable. We become impatient to study more deeply and to find out how far our conclusion is true, and whether we have made any mistake.

Relief and Altitude.—Such a map as we have been considering represents the general relations of the parts of the country as to elevation or altitude, or shows the *relief*, as we may say. We usually speak of the exact height of a hill or a mountain as its *altitude*, meaning thereby the exact number of feet that the top of the elevation is vertically above the level of the ocean. It is very rare, however, that a person can stand at the foot of a mountain and see its whole height in one glimpse.

Such a thing is impossible, of course, unless one view the mountain from the seashore, as, for instance, in Alaska, where one can stand on the shore and see the top of Mt. St. Elias, 18,010 feet high, or again in Japan, where from the sea one can look to the top of Fuji-yama, 12,440 feet high. Even under such favorable conditions, however, we cannot really appreciate the height of the mountain, because of the distance of the peak, and for other reasons

FIG. 2.—A VIEW OF MOUNT WASHINGTON AND NEIGHBORING MOUNTAINS, SHOWING RELIEF OF REGION.

that make it difficult to judge the height and size with accuracy.

Usually one views a mountain from its very foot, or from a very short distance from the pedestal on which the mountain is placed, and sees only a certain part of the whole height of the mountain, as in the White Mountains in New Hampshire, where one stands at the height of about 1,200 feet as he views the summit of Mount Washington rising about a mile above him, but with an altitude of 6,291 feet. (See Fig. 2.) Hence we need to recognize the difference between exact altitude, which

can rarely be seen, and visible height. The visible height of a point above the adjacent lowland is spoken of as its *relief*, and a country with many sharp, high peaks would be said to have a strong relief. A flat and monotonous country, where there were few elevations and no deep river valleys, would be of slight relief.

It is the relief of the region in which we walk, and not its altitude, that makes us weary; for it is not the being up, but the going up and down that takes hold of our muscles. In very high mountains, however, where the air is thin, and breathing difficult, the effects of altitude are important. We need to keep in mind very clearly this difference between relief and altitude, for we can see and test relief every day, whereas we can but rarely test the altitude of a region. Indeed, the hundreds and thousands of people in the United States who have never seen the ocean have not had a chance to measure by their eye the exact altitude of any feature of the earth's surface.

From a map showing the relief, then, we must not expect to get exact ideas of a region, particularly when a map represents a large area in a small space. We can get general ideas only, but yet such general ideas will allow us to see that the country may be divided roughly into mountains and plains, or, as we may perhaps better say, highlands and lowlands; we can find out something of the general height of the lowlands, so that we may know whether to call them plains or plateaus; we can get something of the general direction of the mountains, and see the difference between an individual peak, like a volcano, and a series of peaks, such as we find in mountain ridges or ranges.

CHAPTER III.

THE LARGER FEATURES OF THE CONTINENTS—*Continued.*

Mountains.—Indeed, we should notice, as we study the maps of the various continents, that single mountains are rare. What is more common is a mass of highlands above which certain peaks rise conspicuously. These highest peaks are often points of interest because of the view to be obtained from them, perhaps at the expense of much hard climbing, accompanied by more or less danger. (See Fig. 3.) The mountain peak, however, is not the barrier that the traveller finds in his way as he attempts to cross a country, for he can avoid the peaks by going through the passes or gaps between them. (See Fig. 69, page 145.) The mountain peaks are left by themselves, and are only sought out by the professional tourist (see Fig. 4) or mountain climber, and occasionally by scientists who desire the pleasure and honor of having reached the top of some extremely high and almost inaccessible peak, or the credit of having found some particular features of that top hitherto unknown. The mountain mass making a highland is the great barrier to easy travel, and thus needs our first and our most careful attention.

Continents and Highlands.—As the highlands stand up rigid and strong as compared with the neighboring lands, we may think of them as the skeletons of the continents, giving us the general idea of the whole continent,

just as the skeleton of an animal gives us a general idea of the animal's appearance when alive.

Taking our own continent of North America as an example, we find on the west a great highland known as

FIG. 3.—CLIMBING A HIGH AND STEEP-SLOPED MOUNTAIN IN ENGLAND.

the Cordilleran Highland, commonly divided into several systems of mountains. From the western slopes of these mountains we find the rivers flowing into the Pacific Ocean, from the eastern into the Gulf of Mexico, or in the far north into Hudson Bay or into the Arctic Ocean.

Between these river systems we find a large area known as the Great Basin, in which the water accumulates in depressions that have no outlet to the sea, of which Great Salt Lake in Utah is an excellent example.

We find, then, that the Cordilleran Highland consists,

FIG. 4.—AN INCLINED COG-WHEEL RAILROAD ON PIKE'S PEAK, COLORADO, USED TO CONVEY TOURISTS UP THE STEEP SLOPES.

throughout part of its extent at least, of an eastern highland and a western highland, with an elevated area between, with what we call internal drainage. Such an arrangement exists in other continents, and may almost be said to be an essential feature of the highest and broadest highland of a continent.

On the east of North America we have the Appalachian Highland, composed of several series of mountain ranges, and from which many large rivers flow toward the ocean in several directions. Much of the water goes to the west into the Great Central Plain, there to join the waters from the eastern slopes of the Cordilleran Highland in the great Mississippi River. Some of the other rivers of the Appalachians flow directly to the Gulf of Mexico, or to the Gulf of St. Lawrence by way of the St. Lawrence River; but most flow directly to the Atlantic Ocean across the Atlantic Plain which lies to the east of the highlands. North of the St. Lawrence River we find a faint height that determines whether the waters of the region shall go to the St. Lawrence or to Hudson Bay.

The important physical features that North America has in common with other continents are the greater highland (of three parts, as we have seen), the lesser highland, and the central plain. Considering this arrangement of highlands and lowlands as the skeleton feature of a continent, we find that Eurasia (Europe and Asia), North America, South America, Africa, and Australia may be called continents. Though this general arrangement of highlands and lowlands is found in each continent, it should be noted that the greater highland is not always on the western side of the continent, as is especially well shown in Australia.

Lowlands.—Turning now from the highlands, which we have called the skeletons of the continents, let us look for a moment at the lowlands, which may be likened to the flesh between the bones of the skeleton, which give life, meaning, and form to the continents as a whole. We have already seen that in lowlands the relief is in general not strong, and, of course, the altitude, from the

name, is relatively low. We have seen that highlands from their essential character are unfavorable to human occupation, except for scattered herdsmen or lumbermen, or possibly miners, and that the whole aspect of a highland is forbidding and repellent to one seeking a perma-

FIG. 5.—A LOWLAND IN CENTRAL NEW YORK VIEWED FROM ADJOINING UPLAND. NOTE THE POSITION OF THE TOWN, RAILROAD, AND RIVER.

nent home with his fellows. In contrast we find the general character of a lowland, other conditions, such as climate, being favorable, inviting to life, and especially to human occupation and activity. (See Fig. 5.) The lowlands, and especially the great lowlands about some of the great rivers, have long been the seat of the most numerous population and greatest human activity, be-

cause the conditions there are most favorable for agriculture, commerce, travel, and all the necessary industries of life.

When we come to consider more in detail the features that make different industries possible, we shall see why lowlands, more than highlands, offer the requirements of soil, water, slopes, etc., which enable large numbers of people to congregate and find the means of living.

It is not enough, however, to look broadly at a continent as a whole, as we see it on a map, and to say that here men would live, and here they would not; such an exercise is useful as giving us a clue to those parts of the continent that will be the most interesting and instructive for further study. But such a single glance cannot prove this relation of highlands and lowlands to life. If, however, we should find this relation in several instances, we should have more confidence in our general view. The neighborhood of New York City furnishes a good series of illustrations of these conditions, which we may take as an example.

Greater New York.—The area included in Greater New York may be divided geographically into four rather distinct parts, each with its peculiar features of topography, or land shapes, and its own peculiar character of living. (See Fig. 6.) First should be mentioned the thickly settled area of the Borough of Manhattan, a somewhat rolling country, mostly concealed by flagstones and houses, interrupted occasionally by masses of hard rocks making uplands (we can hardly call them highlands), seen particularly in some vacant lots and in such preserved areas as Central Park, Mt. Morris Park, Morningside Park, etc. The conspicuous elevations of Morningside Heights and Washington Heights are the regions of the harder

rocks and the thinner settlements. The rest of the borough is low and sandy, and was once the seat of a

FIG. 6.—MAP OF GREATER NEW YORK, SHOWING THE SEVERAL DIFFERENT PARTS OF THE REGION.

number of small streams and ponds, long since superseded by sewer pipes. Similar areas of irregular upland and lowland compose the Borough of the Bronx.

The lowlands of the southern portion of the Island of

Manhattan and of the flats of Harlem have always been devoted to business houses or to residences. As the population has become more numerous, some of the lower uplands have been occupied by homes or business blocks, but the greater heights on the west side of the

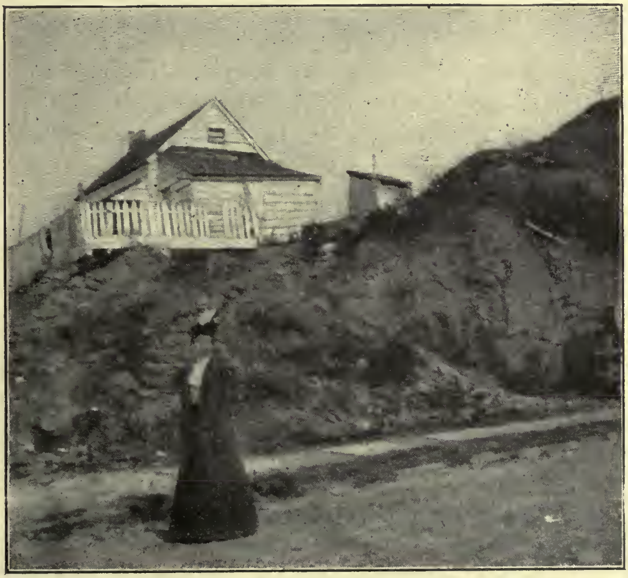

FIG. 7.—A "SQUATTER'S" HOME ON A ROCK, MORNINGSIDE HEIGHTS, NEW YORK CITY.

city have in part been made into parks and in part left unoccupied, or given over to such charitable, religious, or educational institutions as Columbia University, St. Luke's Hospital, the Protestant Episcopal Cathedral, etc. Similarly on Washington Heights, the extension of the same ridge north of 125th Street, we find many

large orphan asylums, homes for invalids, the site of the College of the City of New York, etc.

The occasional patches of good land among the rocks of these heights have, it is true, been occupied by small farmers, but the population has not been numerous. As the herdsmen of Switzerland build their summer homes near to occasional patches of good ground in the rocky heights, so the so-called "squatters" in Harlem and other parts of New York City have built their homes on the rocks near to the pasturage for their cattle and goats, and to the small lots capable of raising a few vegetables and flowers. (See Fig. 7.)

As the two boroughs mentioned are somewhat similar in their features, so are the Boroughs of Brooklyn, Queens, and Richmond. (See Fig. 6.) In each of these there are three separate divisions: to the northward and westward an irregular rolling, hilly country, abruptly ending in a steep slope to the southeast and south, that faces a plain. The plain continues to the ocean, and is fringed by a series of recently formed beaches and bays. Within these boroughs, again, we find the same occupation of lowlands, and a general avoidance of uplands. The low plains of Long Island and Staten Island are mostly covered with large truck farms, from which comes a large share of the vegetables for the city markets. The heights of Staten Island, Brooklyn, and Jamaica are more used for residences or for parks, as in the Borough of Manhattan.

Summary.—We have seen that the world consists of air, water, and earth; that the earth underlies the water and air, and that the continents are but the higher parts of the rock earth not covered by the water; that the line where the earth and water meet is called the shore

line or coast line, and that the shape may be of great importance. Further, looking at the land, we have found that the continents, the home of man, are composed of lowlands and highlands, and that on the form and arrangement of each depend many things in reference to man's life; and, finally, that in a general way we should expect man to be more numerous in the lowlands and more scattered in the highlands, as we have seen illustrated about New York City. Let us next see what men can do to make a living amid such different conditions, and, if possible, some of the reasons for their mode of life.

THE INDUSTRIES OF MEN.

CHAPTER IV.

CENTRES OF INDUSTRY.

Importance of Work.—There is a well-known saying, " Man cannot live without work," and certainly it is true that, the world over, men must labor to get the necessary food and clothing from the earth, or from the animals and plants of the earth. The savage, living amidst the luxuriant vegetation and the numerous animals of the tropical forests, would seem at first sight not to have to work for a living. But the animals must be ensnared and killed, and the fruits and roots must be gathered, and perhaps dried and cooked, before the savage can enjoy the riches about him. The labor, perhaps, is small, and the return large; but it is often more difficult than it would seem at first, and however much the savage may seem to us a lazy, indolent creature, there are times when he, like his neighbor the large reptile, must wake up to the demands of hunger, and work for his food.

If we pass from the tropics to the far-distant polar lands, we find labor even more necessary in order that the native may live. The Eskimo, living where he cannot till the land, must depend for food upon the animals and fish that he can catch. He must, by patient and hard work, secure his food and most of the necessities of

life from the sea. Hard work is his daily experience. His main industries are hunting and fishing.

If we look about us in the temperate lands in which the white man mostly makes his home, we find that the simpler industries of hunting and fishing (except sea fishing), by which man wrests his food first-hand from nature, are largely confined to the wild parts of the world into which man is just penetrating. In the forests and waters of the uninhabited frontier of the country we find hunting and fishing for food and furs; but in the more thickly settled countries people live mostly by other industries, many of which demand that they shall dwell thickly together to secure a good result from their labors. Again, we find that the individual person is not himself securing all he needs in life by his own direct labor, but that he is devoting himself to doing some one thing well, with the expectation of trading the result of his work for the other things that his neighbors are producing—things that he must have in order to live.

If we go to the mountains of Tennessee and Kentucky, we shall find the people in general living in scattered, small settlements, perhaps but one house to a place. Not infrequently we shall find each family raising its own vegetables, and perhaps tobacco, for use during the whole year, raising its own hogs and chickens to furnish meat, weaving and spinning its own clothes, and making its own flour from the products of the fields. Here trade and commerce are almost unknown, for there are few commodities raised in sufficient abundance to sell, and few people to buy, even if there were anything to sell. What trade there is, is largely confined to the exchange of products at the country store for certain goods that cannot be raised. This form of direct swapping without

the use of money is known as barter. Such a method of living is not profitable or easy, for it does not allow people to have many things other than those that are absolutely necessary.

Centres of Life.—People have by experience found it pleasanter and of greater advantage to live in more or less thickly settled communities or centres, and there to carry on many different industries, each man doing one task and doing it well. In the early history of this country, however, people came to live together not only for such mutual help, but because they could thus better protect themselves against the Indians and wild animals. As a result we have villages, towns, or cities, varying in size from a population of a dozen to that of millions. The towns and villages have increased in size and number very rapidly in the last fifty years, until we have come to think that the prosperity of a region is shown by the number of large cities.

In each centre of life we usually find some one conspicuous industry that forms the trade or occupation of the majority of the people, or there is some one good reason that has caused people to gather there in numbers. We describe the centre by its principal industry, and from this it gets its reputation. For instance, we speak of New York, or Chicago, or Liverpool, or Calcutta, or Rio Janeiro, as great commercial centres, meaning that there people trade, gathering products from the country about them to send to other countries, and bringing in return the commodities from abroad that are needed at home. We speak of Lowell, Massachusetts; Paterson, New Jersey; Manchester, England, and other similar cities as manufacturing centres, meaning that there people, by means of machinery and their own hands, turn the cotton, or

iron, or other so-called raw product into the finished utensil or article of clothing, etc. Thus there must be centres of different kinds in the different parts of the same country, so that by trade each person may secure most of his needs without difficulty.

If we attempt to enumerate the various kinds of centres, we shall find the following to be the most important groups :

Commercial centres, where trading is carried on on a large scale; agricultural centres, about which are large farms or plantations from which come the grains, vegetables, and fruits that are used for food, or the cotton that is made into clothing; grazing centres, about which cattle, sheep, hogs, or horses are raised in large numbers for food, or for other uses (grazing centres would include the dairying centres from which come our milk, butter, and cheese); lumbering centres, at which timber is cut to supply lumber for houses, factories, stores, furniture, ships, to make wood pulp for paper, etc.; manufacturing centres, at which raw products are made into needed articles for home use and commerce; mining centres, at which valuable minerals, ores, or rocks are taken from the earth; fishing centres, from which men go to catch the fish of rivers, lakes, or ocean; and, finally, a group of centres that may, for lack of a better name, be called scenic centres, to which visitors are attracted by beautiful scenery, good air, a chance for rest, or by some object of historical interest. Some centres, producing products that are absolutely necessary, are, of course, much more important than other centres. As we must eat, and have wool or cotton for clothing, agricultural and grazing centres may be said to be the most essential to each one of us. Similarly, there must be manufacturing centres, where cloth-

ing is made from the raw cotton or wool, and where other needful articles are produced.

One part of a country is best fitted to be one form of centre, and another another, inasmuch as success in any of these forms of industry demands a special series of conditions differing from the conditions in any other centre. Although there are many forms of industry often carried on together in any large city, the city gets its reputation from that kind of work for which the conditions are by nature the most favorable, as is well illustrated in New York City, where every sort of industry is carried on, but where commerce is the most important.

If we know the conditions that make any particular industry possible or profitable, we shall be able to understand the more important reasons for the growth of some of the larger cities of the world, and the distribution of industries in our country and others. From such a study we shall get a better idea of the geographic conditions of the inhabited part of the world, for we shall study the world not as so much land and water, but as the home of the many varied forms of life.

CHAPTER V.

CENTRES OF INDUSTRY—*Continued.*

Commercial Centres.—In order to be a good centre for trade, a town must be so situated that it can secure a large amount of goods to be sold with the least cost for carriage from the farm, factory, forest, or mine. It must have, also, a ready means for sending the goods away to other cities, or other countries, at small cost and with little delay. Chicago, Illinois, for example, is so placed at the southern end of Lake Michigan that it is the very centre of the great farming country of the prairies, and naturally draws to itself the products of the region round about, especially grain and beef. It also has easy railroad connection with all its neighboring cities, and by several direct routes with the great seaports of the Atlantic coast, particularly New York and Boston. No less important is its ready water connection with the Atlantic, by means of the Great Lakes, the several canals, and the St. Lawrence River. By its position at the centre of a large area from which it can draw goods by railroad, it is like a garden spider which has a great web spread over the grass, from any part of which it can gather prey. Once gathered, the spider withdraws into its round, tunnel-like hole, and gets rid of its spoil. From wherever gathered, the prey disappears by one route. In a similar way we find that the larger part of the goods gathered to Chicago are sent eastward, along the routes mentioned, to the great seaports.

New York City is another example of a great seaport and commercial centre. Here the wonderful ease of communication with Chicago and the other large cities of the great West, by means of the Hudson River Valley and the Mohawk Valley, insures a large supply of products for exportation. The deep, large, and protected harbor, the nearest of the better Atlantic harbors to the great ports of Europe, gives ready access to the largest vessels of all the commercial nations of Europe and South America. Again, the protected pathway of Long Island Sound gives an excellent opportunity for coastwise trade with the New England States and the eastern provinces of Canada. For these reasons, and also because of its ease of communication with the West and Southwest, New York has naturally become a commercial centre, and the greatest in the United States. Other examples might be given, but these two give us all the facts necessary to account for the growth of a commercial centre.

All commercial centres are not, however, large cities; for any city so situated as to accommodate the country or region round about it will probably be a commercial centre. The farmer who sells his vegetables in a neighboring town and procures groceries there to take to his home is helping make that town a commercial town, in the same way that a large importing and exporting house in New York City helps make that a commercial centre. Something to sell or exchange, a cheap and quick way to carry it, and somebody with energy enough to set the trade in motion are the requirements of a commercial centre, large or small.

But the process of exchanging one form of goods for another on a large scale is not so simple as it would seem

at first. A large commercial city, like those mentioned, must have many large wholesale houses, perhaps each devoted to one thing, like leather, cotton goods, woollen goods, sugar, etc. At such a wholesale house no one can buy a small quantity of goods, and no local customers are supplied, unless it be the large retail stores that buy goods in large quantities. Each such house or firm must also have a large storehouse, where the goods can be kept after they are received, and from which they can be readily shipped. Large commercial and, indeed, all large business centres must also have banks, to accommodate the men who do not pay for goods directly by money, but by checks or drafts on their store of money deposited in the bank. Insurance companies are necessary, to insure the goods that are kept in stock by the large firms. There must be also large railway freight yards, where many thousands of freight cars can be loaded or unloaded at one time. Chicago, for instance, is noted as being the largest railway centre in the world. If a city is engaged in water commerce, there must be wharves and docks that allow vessels to land and discharge their cargoes easily. It is the presence of such wharves on both sides of the lower Hudson River, along the so-called "water fronts" of New York and the neighboring cities in New Jersey, that makes their water trade possible.

As such extensive business demands the activities of many people, a trade centre may grow into a large city, with its thousands of homes, as we find in New York, Chicago, Philadelphia, etc. Large numbers of people demand quantities of supplies, to give them food and clothing, and hence great numbers of stores of all kinds, many places of amusement, quick means of getting from

one part of the area to another, and all the other human activities and devices that go to make up a large city. Most of these conditions exist in a similar way in any business centre where large numbers of people are congregated together, and by their presence help to make the city larger and more complete. A manufacturing

FIG. 8.—A CULTIVATED AREA IN IRELAND. NOTE THE DISTRIBUTION OF THE TILLED FIELDS ON THE MORE GENTLE SLOPES.

city has thus many things in common with a commercial city.

Agricultural Centres.—The most important thing in determining the success of agriculture is land with slopes that can be cultivated. (See Fig. 8.) If the slopes are too steep, the water of the soil will run away too rapidly, and tilling will be difficult, if not impossible. In such an area the soil will wash away after a rain, so that there

can be no surety about a crop once planted staying in the ground undisturbed until the harvest. Next to the need of a slope not too steep to hold the soil is, of course, the need of good soil. There are many things that determine whether a soil is good or bad, but the principal thing is that it contain the materials that the plants require for food. The soils that are found in the

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FIG. 9.—A COTTON FIELD IN THE RICH LOWLAND OF THE MISSISSIPPI RIVER.

lower slopes of rivers are the best, because they are very fine and composed of many different kinds of material. Hence such river lowlands, as we have already seen, furnish the best farm lands, if other conditions favor their use. (See Fig. 9.) Next to the two needs already mentioned is a good climate—that is, there must be plenty of rain, but not too much; there must be plenty of warmth, and a sufficiently long summer for the crops to ripen. Finally, the region must be in easy communi-

cation with a large commercial centre at which the products of the farm can be sold for money, or for goods that the farmer needs. If the farmer wishes to raise fruit or vegetables, or some other thing that must be used as

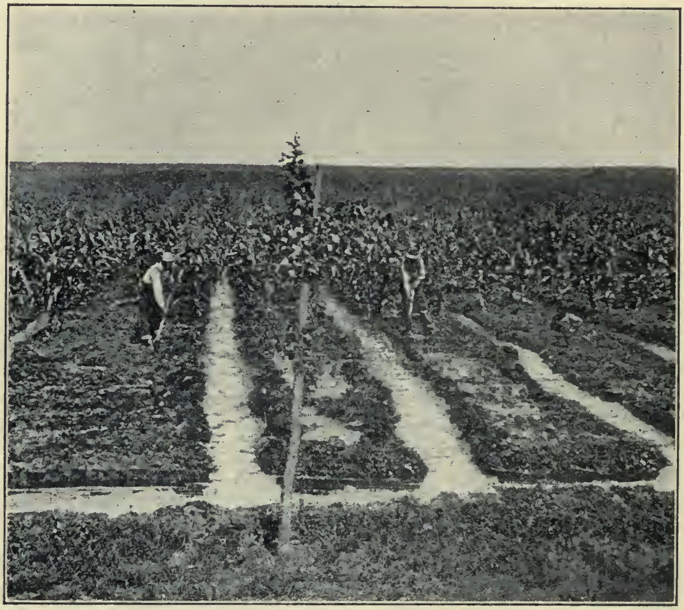


FIG. 10.—AN IRRIGATED FIELD IN SOUTH DAKOTA. NOTE ARRANGEMENT OF DITCHES BY WHICH WATER IS FED TO CROPS.

soon after gathering as possible, then it is, of course, a great advantage to be as near as possible to a large city.

In the vicinity of New York City there are wonderful illustrations of this kind of farming in the low flat plains of southern Long Island or Staten Island, and in the many farms in the valley of the Passaic River in New Jersey, but a few miles from several large cities. Here

we have all the necessary features for successful market gardening, as it is called: a low plain with good soil, plenty of water, and a good climate, within easy reach of a large city that will make use of the products as fast as they are ready for market. In the isolated little fields, now rapidly giving way to apartment houses, in the northern end of New York City we have just as good illustrations of farms, but on a much smaller scale.

If we go to the Southern States and study the cotton, rice, or sugar-cane plantations, or to the Western grain fields, we find the same need of slope, soil, and climate favorable for inexpensive tillage. Here, however, there is no need of a neighboring market, as these crops are capable of being transported to great distances without loss of value.

In the large plantations of the South or West, in the large farms of Pennsylvania or New York, or in the small farms of New England, we find the same need for the favoring conditions we have named. So that we may regard these as the important conditions for farming, seemingly of importance in the order named. This does not mean that agriculture cannot be carried on where these conditions, or some of them, are absent; for where there is too little rain, irrigation or artificial watering of the soil gives the needed moisture. (See Fig. 10.) In the cold weather of the New York winter, crops are grown under glass in small hot-houses, thus securing large profit at a considerable expense of labor and money.

To be profitable, however, farming demands the conditions mentioned; and the Mohawk Valley of New York State with its many large hay and vegetable farms, South Carolina with its rice swamps, Mississippi and

Alabama with their cotton plantations, Illinois and Ohio with their great prairie farms, and the Dakotas with their wheat fields are some of the regions of the United States that are the best adapted naturally for agriculture, and they are renowned the world over as among the best agricultural centres.

FIG. 11.—A LARGE DAIRY FARM IN NEW YORK STATE, SHOWING LARGE CATTLE BARN, TILLED GENTLE SLOPES, AND STEEPER SLOPES DEVOTED TO GRAZING.

Grazing Centres.—The conditions that make grazing the principal occupation of a region vary but little from those necessary for agriculture. There is the same need for soil that will raise food for cattle and other animals, though the soil need not be of the best. On the larger dairy farms, however, there must be good soil and rich pastures from which the cattle may get the best of food

if the industry is to be profitable. (See Fig. 11.) On the large cattle ranches of the Southwest and West the amount of food on a given area is very small, and thus the cattle wander far and wide to seek the necessary grass. (See Fig. 12.) Next to the need of a soil not too barren to raise food is the need of sufficient rainfall in the growing season, to furnish the soil all the water

FIG. 12.—A GRAZING RANGE IN ARID NEW MEXICO. IN THE CENTRE OF THE PICTURE IS SEEN ONE OF THE INTERMITTENT STREAMS OF THE REGION.

needed. We find, too, that the slopes over which cattle may wander in search of food do not need to be as gentle or smooth as those devoted to agriculture. The country can also be more irregular in shape or topography, more cut up and more interrupted by ledges of hard rock than it should be in an agricultural region. (See Fig. 13.)

We thus see that the conditions for grazing are but varieties of the conditions for agriculture. Indeed, if we

go to a New England or a New York farm, we shall usually find a certain part of the farm devoted to pasturing cattle, horses, sheep, or hogs. The lower lands and the smoother, more gentle slopes are devoted to the vari-

FIG. 13.—A ROLLING VERMONT FARM, WITH ALL BUT LOWER SLOPES DEVOTED TO GRAZING AND FORESTS.

ous crops, to hay or grain fields. As we climb the hills and the slopes grow more steep, or as we descend into the areas too wet for ploughing, we find the pasture lands, and perhaps at the top of the hills we may come into the woods in which the cattle may have a chance to

feed. In some parts of the country, as, for instance, in Arizona and New Mexico, cattle, sheep, and goats will be found in the forests to the summits of mountains that are more than a mile and a half in height.

The other condition noted as important in determining the success of farming is nearness to a good market. This would seem also to be an important element in grazing, and it is in some cases. But if the grazing consists in the raising of cattle, horses, sheep, or hogs for the market, then nearness to a large city is not so important, as the cattle can be shipped alive long distances at small cost, and be slaughtered at large establishments, such as the great slaughter-houses of Chicago or Kansas City. Again, if a region is devoted to the production of butter and cheese, which can be kept for a long time before being used, then an accessible market is not important. If, on the other hand, the dairyman wishes to produce milk and cream for market, nearness to a large city is very important, for such products cannot be shipped very far without great expense and the danger of spoiling. We thus find milk for people living in New York City coming, for instance, from as far distant as Delaware County, New York, or Pittsfield, Massachusetts. About this latter place, and in the Berkshire Hills to the south, are all the necessary conditions for profitable grazing, accompanied by more or less profitable farming. Here on the uplands, bordering the Housatonic River and its branches, are good water, fair soil, rugged, rough land, often with steep slopes, all within a few hours of a large market. Dairy farming is consequently important and successful in this region.

Lumbering Centres.—In certain parts of the world, as in the Adirondacks in New York State, nearly all the

land is covered by forests. In some cases the forests are, as we say, "primeval"—that is, they have never been used by man except as a pleasure or hunting ground; in other cases the trees are rapidly being cut from extensive areas for use in various ways. The early settlers on the Atlantic coast, especially in New England and about New York City, had to remove the forests before they could attempt any farming, or even get a clearing large enough so that their home in the centre would not be open to attack from Indians in the forest. In the mountain forests of Tennessee, Georgia, and Alabama one frequently finds a school-house in a clearing in the woods. The school-house has been located so as to be accessible to many families and may be out of sight of any house. (See Fig. 14.)

FIG. 14.—A LOG SCHOOL-HOUSE IN A FOREST CLEARING IN ALABAMA. THIS HOUSE IS ALSO USED AS A CHURCH.

As the population has increased, the forests have been removed to make room for farms and towns, until now there are no extensive forests in the United States except in somewhat inaccessible regions, or on lands that cannot be devoted to farming or grazing. Where small

patches of forest occur on farms, they usually are found where the slopes are most steep, the soil the poorest, and perhaps the visible rocks the most numerous.

Thus we may sum the matter up by saying that where soil, slope, and inaccessibility to market all unite to render other ways of getting a return from the soil impossible, we may expect to find forests.

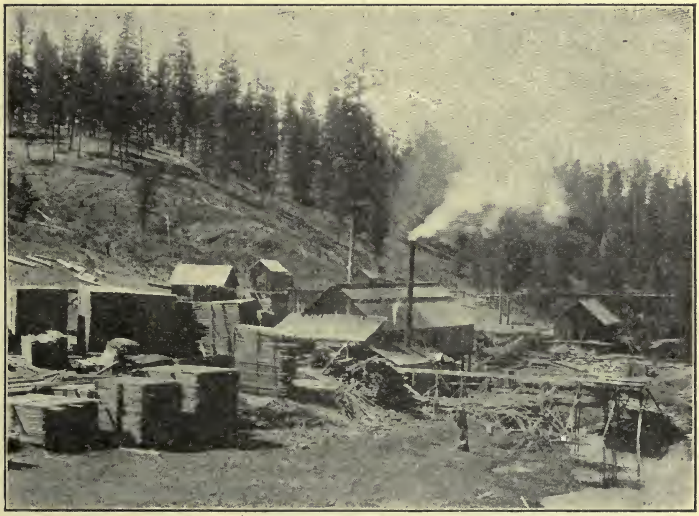


FIG. 15.—A TEMPORARY LUMBER MILL AND CAMP IN WASHINGTON.

In those regions where the forests are now being cut for lumber or for wood pulp which is made into paper, men are gathered together, often in large numbers, in what may be called lumbering centres. In some cases, however, especially in parts of the northern United States, lumbering is carried on only in the winter, when the ground is covered with snow, and the rivers and swamps frozen so that men and teams can go easily in

any direction. Lumbering camps thus may be centres of periodic activity, and, like some other centres, practically deserted at certain seasons. (See Fig. 15.) Lumbering towns, where lumber is sawed and prepared for market, and from which it is shipped, are, on the other hand, centres of continual life. In each case the peculiar geographical conditions that have made lumbering profitable and possible are the cause of the gathering of people in numbers.

CHAPTER VI.

CENTRES OF INDUSTRY.—*Continued.*

Manufacturing Centres.—Manufacturing centres, at which raw products of the earth are changed into the finished goods of commerce and trade through the agency of machinery, and of the men and women who manage the machines, are now among the most important places in the world. When one speaks of manufacturing, the first suggestion that comes to his mind is power, some force of nature that man can turn to his own use to aid him to work more rapidly and to better advantage than by his own hands. The power that may be employed varies in different places. In some places dogs and horses, or perhaps even men, by means of a treadmill, produce power of great value. For instance, on some farms horses furnish power for sawing wood, cutting up corn-stalks for cattle, and dogs may churn the butter. Our usual idea of the power for manufacturing, however, is either steam or water power. (See Fig. 16.) In the early settlement of this country there were many towns founded near waterfalls that gave power. Some of these towns survived, and because of the water power, later aided by the possible steam power, have become great manufacturing centres. The name of the town often suggests to us the water power which primarily was the cause of its growth, as in the case of Fall River and Turners Falls, Massachusetts ; Glens Falls and Little Falls, New York ; and Bellows Falls, Vermont.

A good-sized waterfall is a source of great power (see Fig. 16), but whether the presence of a waterfall will give rise to even a small manufacturing centre depends on several other conditions. As steam makes manufacturing possible now where it was not possible one hundred years ago, and as the coal for making steam can be brought great distances at relatively small cost, water has largely gone out of use as a power.

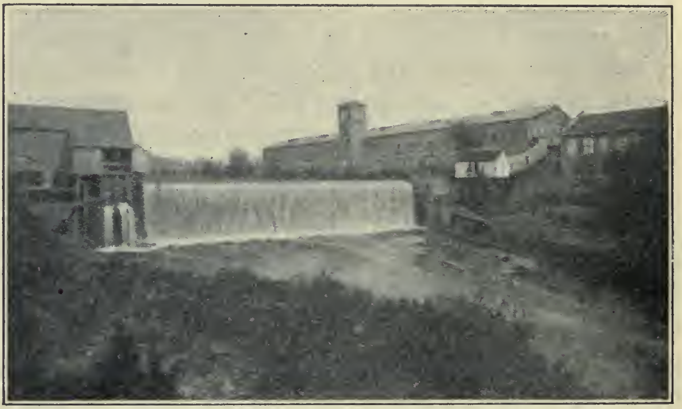


FIG. 16.—A COTTON MILL RUN BY POWER FURNISHED BY A GLACIAL WATERFALL.

The next thing in importance to power to do work is some material to work with. The raw products should therefore be near the power which is needed for manufacturing, and not too far distant from the markets where the finished product can be sold. Some raw products and some forms of manufactured goods, from their value or from their ease of transportation, can be carried long distances, as, for instance, in the case of cotton brought from Georgia, Alabama, or Texas to Massachusetts and

Maine, or hides from South America to the tanneries and shoe factories of Massachusetts. In other cases the raw products cannot be transported long distances, and the manufacturing must be done close to the region of production. For instance, iron, which is very heavy, and which may contain more than a third waste as it is brought from the mine, must be prepared for market close to the mines from which it is secured, so as to save the cost of transportation. Pittsburg, Pennsylvania, is an excellent example of such a centre near to the iron mines. On the other hand, some small towns in Georgia and Alabama, at a distance from one or more of the three things necessary in iron making—*i.e.*, raw iron, coal, and limestone—never grew as their founders had hoped.

Mining Centres.—In considering mining we shall use the term in a large way, to include all the different forms of getting valuable mineral and rock materials from the earth. We must therefore consider quarrying, boring for oil, for water, for natural gas, the digging of clay and sand, the washing of gravels for gold, etc., as different forms of mining. In each case the industry is established at a certain place, because there the earth contains valuable material to be secured by the necessary labor. The character of the rocks at the surface of the earth, or immediately beneath the surface, is, then, the fundamental thing that determines the location and success of mining. As a matter of fact, a great proportion of the valuable mines of the world are found in high and rugged mountainous countries, for the reason that the rocks that usually make mountains contain more precious material than any other kinds of rocks.

Therefore we expect mines to be found largely in places that offer no other inducements for men to make their

homes; that is, where, from the character of the rocks, the small quantity of the soil, and the steep slopes, the more common features are forests, often inhabited by wild animals. The rocks of Manhattan Island, especially in its higher parts, are full of minerals of interest to the collector of minerals, and illustrate very well the general

FIG. 17.—NOME, A MINING TOWN IN ALASKA. THE GOLD IS FOUND IN THE BEACH GRAVELS.

relation between hard rocks, hilly or rugged country, and materials of value in the rocks. If we should go to the granite quarries of Cape Ann or Quincy, Massachusetts, we would find a rough, rugged, infertile country, in general features similar to the regions in Colorado from which come such vast quantities of precious metals. We may thus very rightly conclude that, as a rule, mines are not

very accessible, and that the cost of transportation of the ores is great. Hence the need of a large city as near to the mines as possible, to which the products of the mines may be sent for refining and shipment, and from which supplies may be secured by the miners. Denver, Colorado, at the eastern foot of the Rocky Mountains, is an excellent example in this country of such a mine-made town. The cities like Nome (see Fig. 17) and Dawson City that have lately sprung up in Alaska, because of the finding of gold in the gravels of the Yukon country, are other illustrations of mining centres having all the characteristics of busy and populous mining towns.

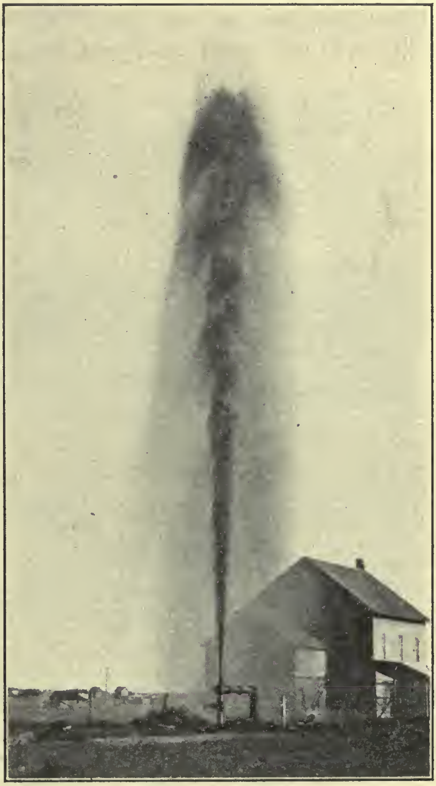


FIG. 18.—AN ARTESIAN WELL IN SOUTH DAKOTA, THROWING A STREAM OF WATER TO A HEIGHT OF NINETY-SEVEN FEET.

Those materials that are secured from the earth in a gaseous or liquid condition, such as oil, gas, and artesian

water (see Fig. 18), are not necessarily found in such rough country as are the ores and rocks considered above. Yet here again it is the character of the rocks and the rock contents that determines the location of the mining centre. The manufacturing of these products may be carried on

FIG. 19.—CLAY FIELDS AT HAVERSTRAW, NEW YORK, SHOWING METHOD OF QUARRYING CLAY FOR BRICKS.

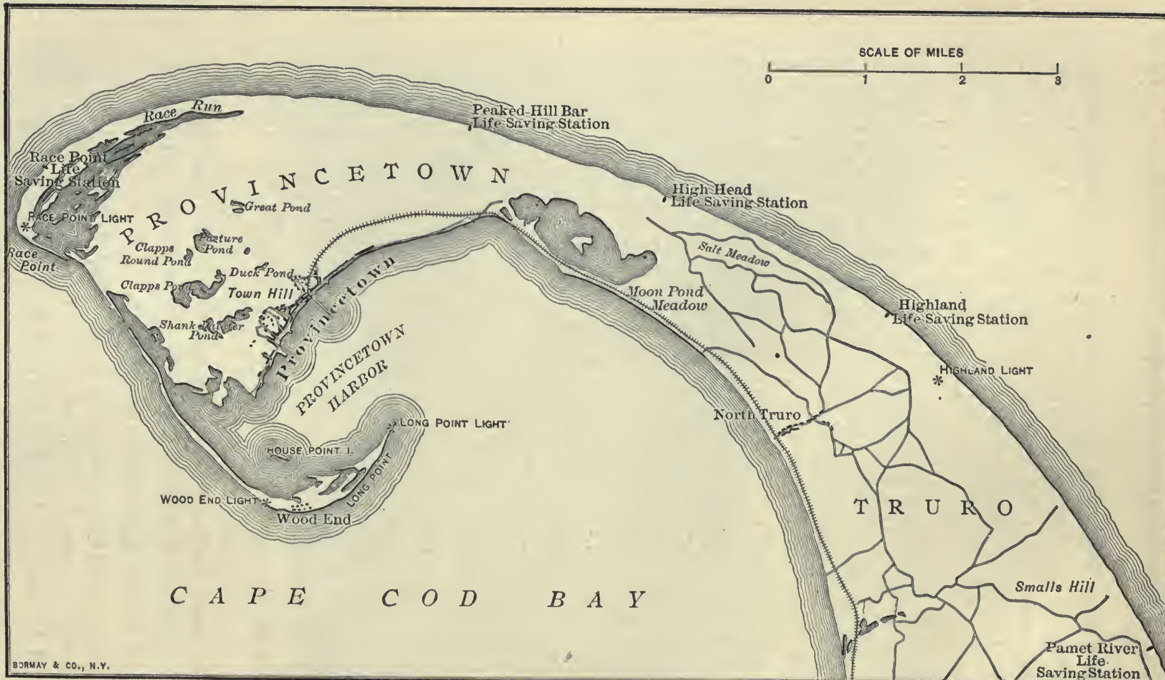
near the place where they are dug, so that a city or town established in such a region would be in part a mining and in part a manufacturing centre. This is true in a number of places in New Jersey and New York (see Fig. 19), where the clays for bricks are manufactured close to the pits from which they are secured.

Fishing and Hunting Centres.—In some places along the shores of our oceans, rivers, and lakes, people are gathered together in large cities or small villages, to cure and sell the fish that some of the men of the community have caught in the neighboring waters or in the distant parts of the ocean. Sometimes the fish is sold fresh, sometimes it is cured or salted, and in some cases it is canned. In each instance the centre of industry is determined by the chance for fishing. In sea and lake fishing a good harbor is a necessity, and nearness to fishing grounds is another important need. Hence we have Gloucester and Provincetown (see Fig. 20), two famous fishing centres on the coast of Massachusetts, near the so-called "fishing banks" of the neighboring Atlantic. In the days of fishing for whales by sailing-vessels, Nantucket and New Bedford, Massachusetts, were also fishing centres known the world over, because of their many vessels that went on long whaling trips to the most distant part of the oceans.

In some instances, as at Portland, Oregon, the fishing centre is a great manufacturing centre, where the fish, in this case largely salmon, are cured and canned for shipping to all parts of the world. Similarly we have fishing centres where oysters are gathered, as in Chesapeake Bay; where lobsters are caught, as along the coast of Maine; where small food fishes are caught, as in the many bays along our northern Atlantic coast.

In each case the centre is determined in its position by the geographical conditions that make it possible to carry on fishing better there than elsewhere.

Another activity commonly associated with fishing is hunting, not so much for food as for furs. Men hunt for food and for sport; but the former is done by savages or



LIFE SAVING STATIONS ▬ LIGHT HOUSES * RAILROADS

FIG. 20.—A MAP SHOWING LOCATION AND PROTECTED NATURE OF HARBOR AT PROVINCETOWN, MASSACHUSETTS. THE WRECK PICTURED IN FIG. I OCCURRED ON OCEAN SIDE OF CAPE.

by men who are exploring a new country, and the latter by men who go into the wilderness for a time, and lead a rough, wandering life of pleasure. Hunting for furs is an occupation in many of the almost uninhabited regions of the world, as in northern Canada, Russia, and Siberia. Years ago the famous Hudson Bay Fur Company had many forts established throughout the remote regions of Canada, from which men went forth on solitary expeditions for furs, or at which the furs were bought from the Indian trappers who wandered through the forests seeking the wild animals. Rarely are large numbers of people gathered together at one place for hunting, so that we cannot speak of hunting centres as large and permanent villages. Yet hunting is the occupation of many men in the rough, rugged, mountainous regions where no other occupation is possible, or in the cold, barren countries where the land may be low and more or less level, but almost inaccessible. Thus, again, the character of the country as to slope and climate determines whether a region shall be the home of wild animals or of men — that is to say, the geographical conditions determine where hunting centres shall be found.

Scenic Centres.— The last of the centres of life for civilized men that we need to consider is what, for lack of a better term, we have already called a scenic centre. By this is meant a settlement of greater or less size, and of more or less permanency, made near some object of interest to which people will make visits from great distances. The summer resorts near New York City, such as Coney Island, Long Branch, etc., are excellent examples of one kind of such scenic centres. Here, during the season when people make visits to the seashore, we find really large cities that may be almost depopulated during the

cold seasons. There are many forms of such scenic centres, some of which, like a local summer resort, attract only people from a short distance; others, like Niagara Falls, the cañon of the Colorado, etc., may be known throughout the civilized world. The most important kinds of such centres are shores either of the sea or of a

FIG. 21.—THE GORGE OF THE RHINE, VIEWED FROM THE UPLAND, AND SHOWING THE LOCATION OF A TOWN AT THE BASE OF THE CLIFFS.

large lake; mountains, like the Catskills in New York or the White Mountains in New Hampshire; great gorges or cañons, such as the cañon of the Yellowstone in the Yellowstone National Park, the gorge of the Rhine (see Fig. 21); forests with their game, as in the case of the Maine woods; rivers and lakes, such as exist in the Adirondacks; falls of rivers, such as the Shoshone Falls

in Idaho; caverns, such as Luray in Virginia, Mammoth Cave in Kentucky, Howe's Cave in New York; springs, such as those at Saratoga or Avon, New York, or Colorado Springs, Colorado; and places of some historic interest, such as the great battle-fields of Lookout Mountain, Chickamauga, and Missionary Ridge, in Georgia and Tennessee.

In almost every case the underlying cause of an interest sufficient to attract people from great distances is some object that has a geographical reason for being. Nearly all the illustrations that I have given have been geographical, for even a battle-field has its geographical reasons for being. It was the geography of the field that made it a favorable place for the holder, and hence desired by the enemy. The strategic position that the other side covets in war is one of such a geographical character as to be easily defended, and hence of great value to the army holding it. The battles of Bunker Hill, of Lookout Mountain, and Manila were all determined in their place by the topography of the region.

Summary.—Looking back for a moment's review of the various centres we have considered, and of the causes that have largely determined them, we find a few topics occurring again and again. Relief and slope, together with climate, are the most important conditions. The soils, drainage, etc., which depend largely upon the topography, are also of great importance, and, together with the geographical positions of the great water bodies, such as the seas and lakes, and the form of the coast line, are to be considered as important geographical reasons influencing the character of life in all parts of the world. These topics, then, are those that need the greatest study if we are to understand geographical conditions, and it

is to these that we must devote the larger part of our attention.

We should not, however, forget that all the riches of the world were here, that all the conditions were favorable geographically for the development of human life, long before they were utilized. We speak of this or that geographical feature being the *cause* of some great step in human progress; but often fail to remember the part that *man* has played in taking advantage of these conditions. The great Mohawk Valley was the best line of communication between the Atlantic seaboard and the interior of the United States long before the Atlantic received its name, or the United States were dreamed of; but it became of great service only when the Europeans took advantage of it. Again, we hear it stated that, given coal and iron, a nation must be great: the geographical reasons exist, and hence there must be advancement and success. This is true in England and in those parts of the United States where coal and iron have been developed; but China, with its great riches in these lines, is not one of the great commercial and industrial nations of the world, in part because the Chinese have not taken advantage of all the important geographical conditions about them. They have lived *with* the geographical conditions, but have not been helped *by* them, or at least not by those conditions to which some other nations owe so much.

The geographical conditions, then, are the underlying causes of human progress perhaps in a greater measure than we think; but they become important in human history and progress only when man takes advantage of them and develops them.

THE ORIGIN OF LAND FORMS.

CHAPTER VII.

CHANGES IN THE EARTH'S CRUST.

WE have seen that the shape and slopes of the land, or the topography of the inhabited parts of the earth, have had an important part in determining the position and character of the several forms of centres we have noted. We should find the same influence of topography on life were we to study plant and animal life in their distribution over the earth. A better knowledge of the various forms of land and their importance would therefore seem valuable, if we are to study the effects of topography with any care.

In order to know any form of topography we must become so thoroughly acquainted with its features as to recognize it and be able to name it when we meet it again, just as it is necessary to know the face of an acquaintance before we can be sure of recognizing him in a crowd. We must remember, however, that to know the name is not sufficient; we may know the name of a plant, and know nothing else about it. After we know the features of the plant, the name becomes of value because it allows us to call to our mind the whole plant, and all its important features, just by remembering the name. So in our study of the earth we must have a knowledge

of the meaning of the shape we are studying before we give it a name.

Thorough acquaintance with any form of topography and with its name does not mean that we shall see every bit of topography in the world. That, of course, is an impossibility. We may, however, know the more common forms which are to be found over the earth, and have in mind at least some one good illustration of each form we study.

Such a study of the forms of the earth can, I think, best be begun through considering the more important ways in which topography is being made and changed by the earth forces that are at work about us all the time.

Permanency of Land Forms.—The suggestion that the forms of the earth are being made may be rather surprising to some of us who have a way of looking upon the features of the earth as fixed and unchanging. We commonly speak of the "everlasting hills"; but the evidence of our daily experiences would tell us, did we stop to observe, that changes are going on constantly, and that the hills are far from being everlasting. For instance, there are several hills in Boston Harbor, Massachusetts, that are disappearing very rapidly under the attacks of the ocean waves, and it will take but a few hundred years to remove them entirely, as many others in the same region have been removed in times gone by. (See Fig. 22.)

Instead of looking upon the features of the earth as fixed, it would be far nearer the truth to think of them as changing rapidly, like the laughs and frowns of a child. From our standpoint, perhaps, the forms of the earth do many of them seem fixed and permanent, for our lives are short, and, except in rare cases, we can see but little

change in the earth in a lifetime. The forces of the earth work on a large scale all the time, and, though they work very slowly, in the course of time they accomplish large results. Indeed, the larger forms of the earth must change with as great rapidity, from the earth's standpoint, as do the little sand and mud forms in the wayside mud puddle

FIG. 22.—A HILL IN BOSTON HARBOR BEING REMOVED BY THE WAVES. THE LARGE BOULDERS IN THE FOREGROUND ARE TOO HEAVY FOR THE WAVES TO MOVE.

of a summer shower from our standpoint. Occasionally there is a sudden and large change, such as when Sandy Hook was separated from the mainland in a great storm a few years ago, or when there is a great landslide, such as that which occurred at Amalfi, Italy, in December, 1899, when a hotel and a large amount of rock suddenly slid into the sea.

Such a way of looking at the earth features, as the results of great but slow-acting forces, gives one the feeling of great power, and makes one full of awe, as when we see a quietly moving but almost irresistible machine slowly but surely move a great weight or cut up a thick bar of iron. Indeed, we soon come to look at the earth as being almost a living thing, like ourselves, doing work and changing as the years go on. The sea wave, the running brook, the moist air, and the ice all have a new interest when we look at them, not simply as objects on the earth to be noted and described merely, but as great forces doing their part of the work of the world, and, as we shall see, usually to our benefit.

The features of the earth, the hills and valleys, the mountains and plains, as we now see them, are but the results of the work of the great earth forces acting on the rock masses of the earth, just as the statue is a form made by the force of man's will and hand out of marble or granite or clay.

In studying the changing forms of the earth, then, we have three things to consider: the materials on which the earth forces work, the manner in which the forces work, and the results—*i.e.*, the forms themselves.

The Materials of the Earth's Crust.—We have already seen that the solid framework of the earth is made of rocks, and that the rocks contain much air and water, even at great depths. It is not enough, however, simply to say that the earth, and particularly the earth's crust, is made of rocks, as though all rocks were alike in character and were changed in form by the forces of the earth with equal ease. It is not necessary for our purpose that we study the rocks and learn their names, and the name and proportion of all the materials that go to

make up any given rock, for such a study is more for a course in mineralogy than one in geography.

For our purpose we may say that there are two great series of rocks, each with many varieties, the first being the rocks that appear in layers or strata, and known as stratified rocks (see Fig. 23); and the second, those that

FIG. 23.—A SERIES OF LAYERED OR STRATIFIED ROCKS BESIDE THE GENESEE RIVER IN NEW YORK STATE. THE WHITE LAYER IS SEVERAL FEET THICK.

occur in great masses without much apparent internal arrangement of the materials, which we may call crystalline rocks. The stratified rocks have mostly been made from the accumulation of deposits of sand, clay, and other materials in some great body of water, just as now we can see the sands accumulating on the seashore in layers. The common varieties of stratified rocks are

sandstones, which are but stratified sand; slates, which are solidified mud; and limestones, which are mostly made of the shells of animals laid down in mud as the animals have died, just as we may see them now accumulating in the mud of flats from which clams are dug, or on the sandy or muddy bottom where oysters grow. A certain kind of reddish sandstone is much used for buildings, especially in our brownstone-front houses; slates were formerly used by almost all children in school, but are now going out of use for this purpose, though they still are often used for roofs. Limestone is sometimes employed for buildings, as in many large white buildings, like Columbia University in New York City and the Brooklyn Institute in Brooklyn. Certain forms of limestones known as marbles are largely used for decorative purposes in houses and for statuary. There are many varieties of sandstone, slate, and limestone, varying in color, in size of particles, or in some other way, and the thickness of the layers may vary from a fraction of an inch to several feet. We thus speak of thin-bedded or thick-bedded stratified rocks, and the thickness of the layers, or strata, is a very important matter in determining the kind of topography a certain rock will make.

Crystalline rocks may be grouped into two great classes, in each of which there is an almost infinite number of varieties: *i.e.*, those that have been formed at a great depth in the earth, and are known as *plutonic rocks*, of which granite (largely used for paving stones) is an example; and those that have been formed on or near the surface of the earth, and are known as volcanic rocks, of which the rocks of the Palisades of the Hudson, and of the Watchung Mountains, New Jersey, are good examples. As the name signifies, crystalline rocks are made of crys-

tals, and were once in such a fluid condition that crystals could form. They are sometimes known as *igneous* rocks, because they have once been heated. The crystals may be so small as to be invisible to the naked eye, or they may be so large as to give the rock a coarse, granular appearance.

Strong and Weak Rocks.—Each of the several varieties included in either great group of rocks is affected

FIG. 24.—A RIDGE AT CAÑON CITY, COLORADO, SHOWING EFFECT OF STRONG ROCKS IN MAKING RELIEF.

somewhat differently by the erosive, or wearing, forces of the earth; but certain groups as a whole are acted on in one way, and certain others in another. In general, we may speak of those rocks resisting the forces acting upon them as hard or strong rocks, as strong gives us the idea of might that the rock shows by its resistance. Granites, many sandstones, and the trap rock of the Palisades are excellent examples of such strong rocks. Strong rocks stand up in ridges or heights, so that we may speak of

strong rocks as *ridge makers*, because of the failure of the forces to wear them away. (See Fig. 24.)

On the other hand, there are the softer, weak rocks that, yielding easily to the forces acting upon them, tend to make lowlands. (See Fig. 25.) Certain varieties of mud rocks and most forms of limestone are usually weak, so that we may expect these rocks to be found largely in valleys, while their stronger neighbors are found on the

FIG. 25.—A CLIFF AND LOWLAND IN ARIZONA, SHOWING STEEP SLOPES MADE ON STRONG ROCKS, GENTLE SLOPES ON WEAKER ROCKS, AND VERY FLAT SLOPES ON WEAKEST ROCKS.

uplands. This is not an absolute rule, however, as sometimes sandstones are weak and limestones are strong; but it is generally true.

The test, then, of whether a rock is weak or strong is its behavior in reference to the forces that tend to wear it away. As these forces are some of them acting everywhere all the time, no rock exposed on the surface of the earth can escape a test of its strength. We can see the work going on if we but observe carefully, and we can see the results in our topography. The forces that we

can see in operation immediately about us are not the only erosive forces of the world; but they are the most important, and a study of them and their work will enable us to understand great and distant topographic features of the world, such as the peaks of the Alps or the Rocky Mountains, the Ganges Plain, or the Valley of the Amazon. Let us therefore look about us and see what forces there are at work, and some of their more important effects.

How the Earth Wears Away.—We have already seen that three great forms of matter make up the world, and we have found the solid rocks of the earth to be the material exposed to the sculpturing of the erosive forces. As a force implies movement, we should naturally expect that the more movable parts of the earth, the air and the water, would be the great earth-sculptors, and in this we are right. We cannot, however, treat these two forces alone; we must treat of four forms of work, because water may erode in any of three forms, as liquid water, as solid ice, or as invisible gaseous vapor. Water working in the form of vapor works *with* and *in* the atmosphere, and we will consider it in association with the atmosphere.

Again, the liquid water may be divided into that which stands at a constant or nearly constant level in some great lake or ocean, and that which is continually running down toward the ocean, as in our rivers ; standing water works in one way, and running water in another, so that we must consider them separately. Finally we have solidified water, or ice, working as frost, as ice on our lakes, rivers, and seashores, or in the great glaciers of such regions as Alaska and Switzerland. Thus we have four great erosive forces to consider, each in some

detail: viz., the atmosphere, running water, standing water, ice.

We must look at these forces not simply as erosive forces, loosening the rock particles, but we must study all the different features of their work. Were the rocks simply worn away, and the particles separated and loosened and left where they were originally found, but little change in the forms of the earth could be brought about. In order to bring about a change, the loosened material, or *detritus*, must be removed, and after a long or a short journey finally left somewhere else. The rock left in the hills that has not been removed will make one kind of form, and the material carried to a distance and dropped will make another, so that any erosive force changes the form of the earth on which it works in two ways, by removing from one place and building at another, just as a sculptor makes from a block of marble both a statue and a pile of chips formed from the pieces he chips off and throws away.

We have, then, three kinds of work to consider under each of these forces: the work of erosion or of loosening the particles, that of removing the bits, and that of depositing or dropping them in a new place. As the atmosphere is the most important and widespread, and the one force that every one can see at work, we shall consider that first.

CHAPTER VIII.

THE WORK OF THE ATMOSPHERE.

Weathering.—The atmosphere—now cold, now hot, now dry, now wet—is always present and in contact with the whole surface of the earth. These changes of conditions give us our varieties of weather. We all know how strong an influence the weather has upon our feelings—a cool, bracing day giving us energy, a hot, muggy day making us languid and lazy. That the effect of the weather may be seen as well as felt is evident in the case of hardened sailors, whom perhaps we speak of as "weather-beaten old salts." We may speak, too, of the weather-beaten shingles of an old house, meaning thereby that the sap and strength of the shingles have been taken away through the influence of the weather; that the wood is gray and punky, and perhaps moss-covered. The shingle is light in weight as compared with a new shingle of the same size, and the evidence is strong that something has gone from the wood. That "something" has been largely carried away in solution in the moisture of the air, as salt is carried away in spray from the ocean. In a similar way the soluble parts of rocks and all materials exposed to the atmosphere are slowly carried away by the moisture of the air. In our cities we see the effects of such destructive work of the atmosphere in the discolored and crumbly brownstone fronts, and in New York City we have a splendid example of weathering in "Cleopatra's Needle," which stood comparatively unchanged

for ages in the dry air of Egypt. It is now crumbling away so rapidly in our moist and changeable climate that it has to be protected from the weather by a transparent coating that keeps the air from the rock.

FIG. 26.—AN EROSION COLUMN AT MANITOU, COLORADO, MADE BY WEATHERING OF LAYERED SANDSTONE OF DIFFERENT DEGREES OF STRENGTH.

The atmosphere in all parts of the world contains some moisture, and thus rocks will be decayed or weathered everywhere, but not with equal rapidity, the rate being slower in dry regions such as the Sahara or our Great American Desert, and more rapid in moist countries. We should therefore expect weak rocks in moist coun-

tries to be worn down with the greatest rapidity, and strong rocks in dry countries to wear the most slowly. All parts of the same rock are not, however, equally strong, and the weaker parts are dissolved or etched away, leaving the harder particles projecting, so that a weathered rock is usually rough. Owing to differences of strength rock masses are sometimes eroded into fantastic shapes. (See Figs. 26 and 27.) A polished granite

FIG. 27.—A SERIES OF EROSION BOULDERS IN ARIZONA. NOTE THE SLENDER PEDESTALS ON WHICH CERTAIN BOULDERS REST.

stone or monument will thus lose its polish and smoothness in the course of time.

The rate of weathering depends, again, upon the ease with which the weathering agents can penetrate the rock, and the amount of surface exposed to the processes at work. Any force that loosens or makes finer our solid rocks gives a chance for water and moisture to penetrate, and makes their destruction more rapid. Water freezing in the minute cracks which are found in nearly all rocks breaks the rocks apart and makes them finer. Roots of

trees and plants, burrowing animals like the ground hog, prairie dog, moles, and common angle-worms, are thus very active assistants in the process of rock decay.

Each splitting into finer fragments exposes more surface to attack, and hence assists the rate of weathering, or erosion. Take a block of marble having six faces, each one foot by one foot: this block contains one cubic foot, and has six square feet of surface exposed to possible weathering and decay. Now cut it into blocks each one inch by one inch, and we have 1,728 pieces, each containing a cubic inch; but each of these will have six square inches of surface, and all together seventy-two square feet of surface. By dividing into cubic inches we have increased the surface exposed to twelve times its original quantity. You can thus readily see that if you divide the original cubic foot into pieces as big as the head of a pin, which would be a large fragment in some kinds of soil, you will have increased the amount of surface so much that one could not appreciate it if expressed in figures.

There are other signs of weathering besides the softening and crumbling of the rocks. When rocks become discolored they grow red or brown or gray, and then give a foothold to the low forms of plants known as lichens, that cover our hard rock ledges in moist regions. It is largely from the detritus weathered from the solid rocks that our soil is made, upon which nearly all vegetable and animal life depends. A fine soil thus is the most fertile, because plants can get food from it most readily. Weathering also rounds off corners, and a weathered pebble, rock, doorstone, or board loses its angularity and becomes rounded and subdued in outline.

As destruction proceeds, we should therefore expect

our cliffs and high ridges to become less sharp and less craggy. Such a contrast of outline and color is very clearly shown by comparing a weathered piece of trap rock from the Palisades of the Hudson with one just broken away. The weathered piece is brown and somewhat rounded, it feels soft, and the particles are loosened on the surface. The other piece is dark green and the edges are sharp—indeed, so sharp that they cut like a piece of glass. It will also ring like a piece of iron when struck by a hammer.

Were the materials loosened from the rocks by the processes I have briefly sketched to remain where they had originated, all our solid rocks would be covered with a thick layer of their own detritus, that would be soft and probably reddish, for all rocks are apt to decay to a red, rusty soil, because of the presence of iron. Indeed, weathering is but a kind of rusting that is so common in daily life. Over a large part of the world such red soil has accumulated in some cases to a depth of several hundred feet, so that the solid, unweathered rock rarely appears at the surface.

The Effects of Gravity.—There are, however, agents at work in most regions removing the detritus, and carrying it perhaps to a great distance from the place of its origin. Any agent which is capable of setting things in motion helps carry the detritus worn from the land down toward the sea, into which it finally comes, and in which it may accumulate to great depths. The wind carries its share in the form of *dust;* the rivers carry very large loads as *sand* or *gravel* or *silt;* the ocean removes a certain amount by the undertow of the waves and the tides, and we again know it as *gravel* or *pebbles.* The everlasting pull of gravity draws downward any loosened rock

materials, and if a large mass from some cliff or mountain moves at one time, we say we have an *avalanche* or *landslide* (see Fig. 28); the rocks and soil are full of water, and in most regions the soils on the hillsides slip or, perhaps better, *creep* slowly downward because the particles are lubricated so that they slip over each other easily.

FIG. 28.—A SERIES OF HUGE LANDSLIDES AT BASE OF AN ARIZONA CLIFF.

Talus Slopes.—One of the best places to see the work of gravity is on the face of some cliff like the Palisades. Here we find at the base of the cliff a steeply sloping bank of rock detritus, very evidently derived from the cliff itself, that is continually being increased by additions from above. The materials are of all sizes, and slip and roll easily under the feet as one climbs toward the top. Such an accumulation, to be found usually at the foot of any weathering cliff, is known as a *talus*. (See

Fig. 29.) If it occur in a moist country, and if the materials have remained long enough in one position so that a soil layer has had a chance to accumulate, the talus may be covered with trees.

FIG. 29.—A TALUS SLOPE AT BASE OF PALISADES. NOTE CLIFF ABOVE TALUS, AND WOODED CHARACTER OF PORTIONS OF TALUS, SHOWING A LONG PERIOD WITHOUT MOVEMENT OF THE PARTICLES.

The detritus thus started downward is on its way to the sea, the lowest place on the earth's surface at which it can accumulate, and the goal of all soil and detritus. Whatever the force that sets the loosened material in motion, its journey to the sea is not a continuous, but

an interrupted one. As the messenger boy who loiters by the way to play with his companions is on his way to his destination until he gets there, so the detritus thus derived from the land is on the way to the sea after it once starts, even though we find the pebbles of the talus or the soil apparently stationary. The motion is slow but sure.

The Wind.—The method thus far considered is not

FIG. 30.—UNCUT AND CUT SIDES OF A SAND-BLASTED PEBBLE FROM CAPE COD, MASSACHUSETTS.

the only way, however, in which the air loosens materials from the rocks. The wind, which has been suggested as a carrier of rock detritus, is also in some regions a powerful agent of erosion. Some of us have had our faces cut and hurt by sleet or sand or dust driven by the wind, and we know from experience that the wind can erode, not by itself alone, but by means of the materials or tools it carries along. In some regions where there is much drifting sand, each particle is a possible chisel to

be used by the wind, and the work of wind erosion is rapid and important. On sandy shores such as that of Cape Cod, in certain parts of Colorado, or in Arabia, at all of which excellent examples of wind work have been found, the moving particles of sand have cut and even polished the exposed surfaces of the rocks. (See Fig. 30.) The process of wind erosion is employed in the making of ground glass, which is ordinary glass, one side

FIG. 31.—SAND DUNES AT IPSWICH, MASSACHUSETTS, SHOWING GENERAL ABSENCE OF VEGETATION.

of which has been exposed to a blast of sand carried by a strong forced draft. The cut and ground side has lost many little pieces under the attack of the wind-driven sand chisels, and feels rough to the touch.

Dunes.—The manner in which wind carries light particles of all kinds, and particularly the fine particles of rock that we call dust, is well known from experience. Go to a sandy seashore on even a very quiet day, and close to the surface of the ground, where the sand is dry,

you will see a thin little skimmering of sand drifting along quietly with the wind. The sand moves on until it strikes some object, perhaps a rock or a pebble, and then a little of it stops on the lee side of the obstruction. More sand follows, and accumulates in a similar manner until great sand-drifts, very much like snow-drifts, are formed. Such sand-drifts are known as sand dunes, and

FIG. 32.—AN APPLE ORCHARD ONCE BURIED BY SAND DUNES AT IPSWICH, MASSACHUSETTS, AND NOW BEING REVEALED, OWING TO REMOVAL OF SAND.

are very conspicuous forms in some parts of the earth, particularly in deserts like the Sahara and on some seashores. (See Fig. 31.) Small dunes may be seen at Far Rockaway and other beaches near New York City, and very beautiful examples occur at Provincetown, Massachusetts, at the southeastern end of Lake Michigan, and at many other places that might be mentioned. Sand dunes may grow to the height of a hundred feet or more,

and are in a way dangerous, for the drifting sand may creep over and cover up valuable property. In one place in Massachusetts an apple orchard was destroyed by the drifting sand (see Fig. 32), and at Provincetown a keeper of the dunes is elected yearly to do what he can to keep the sands from blowing by making vegetation grow over the dunes, and to protect the grass cover after

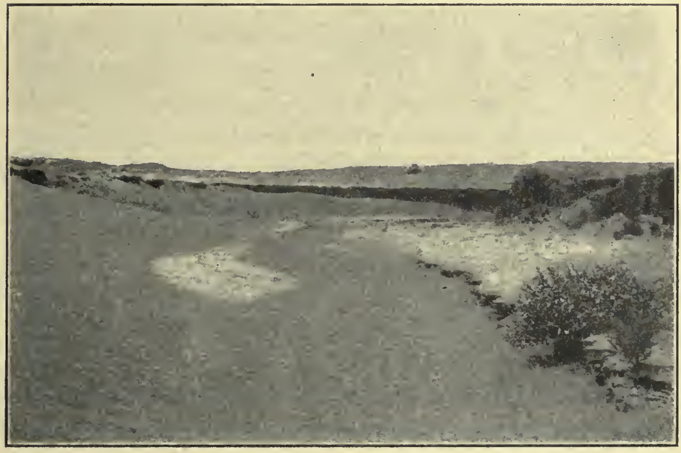


FIG. 33.—A VALLEY IN ARIZONA NEARLY FILLED BY DRIFTING SAND. NOTE THE RIPPLED SURFACE AND ABSENCE OF VEGETATION.

once it is grown. Dunes from their sandy character are very barren, and it is only with great difficulty that any vegetation can be made to take root. Hence dune areas are not thickly settled regions (see Fig. 33), being more the homes, as in the case of our Eastern dunes, of small birds and the haunts of bird-hunters, or possibly the seat of small summer resorts.

Thus we see that wind-made accumulations of sand

may make very large and important topographic features. In a similar way the wind in certain parts of the world has made great deposits of dust known as *loess* deposits. Such accumulations have been formed in China to a depth of more than a thousand feet.

CHAPTER IX.

THE WORK OF RUNNING WATER.

If we were to go to a freshly ploughed field to study the work going on there, we would have difficulty in separating that which is being done by the atmosphere, by gravity, and by running water. The weathering by the atmosphere loosens and makes finer the rock particles; gravity gives them a pull, and perhaps carries them a little way; but the water running down the slope, or creeping through the soil, is the great agent that carries the loosened fragments away. Running water is the force that we should be able to recognize as the most active and most important of all. If, on the other hand, we should go to a forested region, or to one covered with vegetation of any kind, we would probably see but little evidence of the work of running water, as most of the water falling as rain or snow would soak into the ground, and creep slowly down rather than run quickly to the sea, as in a more barren country. Hence the importance of a covering of vegetation in keeping the ground from being rapidly worn or in keeping water in the soil, so that the rivers will not have seasons of flood and drought, but be furnished water slowly.

Running water is the most active of the agents of erosion where the conditions are favorable. With a weak rock, steep slopes, and a large volume of water, necessarily running quickly, the work of erosion is rapid and effective. The opposite conditions give running water but

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little chance to be effective as an eroding agent, and we find it doing another great and important work.

When we think of running water we usually think of it as in some river or river valley, perhaps some valley that we know, and we have a feeling that only in some large stream can we really see the water at work. As a matter of fact, however, the work that one can see in a large stream is very disappointing, because the river is not eroding rapidly, and because the river valley, which we must study in relation to the river within it, is too large to study as a whole, or even to see at a glimpse. The best place to study the various kinds of work done by running water is in some wayside stream that forms in a rainstorm, works rapidly, and ceasing, leaves the marks of its work on the surface for our leisurely examination.

The Erosive Work of Running Water.—The river valley, as well as the river, deserves our attention; for though the running water does the erosive work, it is in the river valley as a whole that we can study the many different features due to river work.

The atmosphere and the river must be studied together, because they work together. The atmosphere and gravity loosen the rock materials and bring them down to the streams, but the streams are usually the most active agents in removing the detritus. Indeed, the river's work is more that of a carrier of the detritus derived from the land than that of an eroding agent. Sometimes the river is likened to a railway train that receives and carries all freight delivered to it, and the atmosphere and gravity to the farmers who prepare the freight for shipping, and take it to the train.

In the upper portions of a river where the slopes are

steep, we find the water rolling fragments along, hurling them one against another, and against the sides and bottom of the channel, thus wearing them finer and finer, and making the channel deeper and deeper. A river can roll along the largest particles when it contains the most water. Hence the rushing torrents formed by spring

FIG. 34.—A STREAM-BED IN THE ADIRONDACKS, SHOWING LARGE BOULDERS THAT CAN BE MOVED ONLY IN TIME OF FLOOD.

floods can carry larger and more rocks than the withered summer streams, and many streams show us in summer a floor of rounded pebbles that were in active motion earlier in the season. (See Fig. 34.) As the stream thus cuts its channel down, it brings its bottom nearer and nearer to the level of the sea, so that the slope grows less, and the river less powerful as an eroding agent. At the same time side or tributary streams cut back chan-

nels into the banks, thus greatly increasing the amount of river channels in a region. (See Fig. 35.)

As it cuts lower, the head of the river creeps farther and farther back, thus lengthening the stream. This lengthening of the stream towards its head, or, as we may

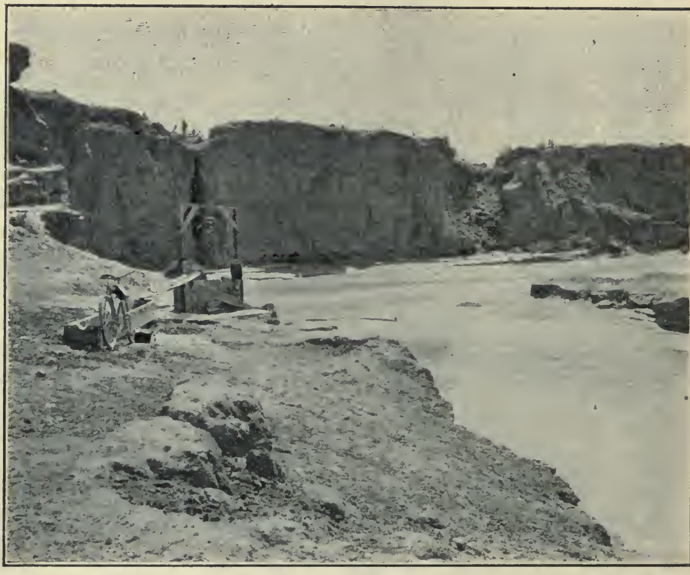

FIG. 35.—A STREAM IN FLOOD, SHOWING UNDERCUTTING OF OUTER BANK AND DEVELOPMENT OF TRIBUTARY CHANNEL.

say, headwards, is very well shown in a clay bank, where we find the upper and steeper portions of the bank continually falling. (See Fig. 36.) The material thus removed, and, indeed, all material that comes into the water, is carried along by the stream as far as it can be, and may be called the *load* of the stream. As the slope decreases, the size of the particles carried by the stream

necessarily grows less and less, for its carrying power grows less and less. When the stream no longer can carry all its load, we say it is overloaded, and when overloaded it must drop that part of its load that is carried with the greatest difficulty; that is, the largest and

FIG. 36.—RAPIDLY DEVELOPING RIVER CHANNELS ON A NEBRASKA BLUFF.

heaviest particles that have been too strong to be worn much smaller with the battering they have received as they have journeyed along. As we go down stream, the slope grows more and more gentle, and hence the particles that can be carried grow smaller and smaller, until finally they float along in the water, instead of being rolled along the bottom. The particles carried along by the

Hudson are seen to be very fine, as may be shown by allowing a glass of Hudson River water to stand undisturbed until its detritus has had time to settle. It is said that the Mississippi rarely carries a particle as large as a pea to the Gulf of Mexico; but the quantity of fine materials carried is enormous, sufficient, it is said, in a year to cover an area a mile square to a depth of more than two hundred and fifty feet.

The detritus thus carried along by a stream, and, as we shall soon see, finally deposited, cannot be ignored in considering a river and its work. Some streams roll their loads along the bottom, and are clear; in other cases the load is floated in the water in the form of fine particles, and we say that the river is muddy; in still other cases there is little visible load, yet the load exists, being dissolved in the water as sugar may be dissolved in water without coloring it in the least. Thus there is no perfectly pure water in any stream, no water free from detritus in greater or less abundance. Hence the detritus is as much a part of the stream as is the water; and any definition of a river that does not include the carried load tells but a part of the story, and is inaccurate as well as incomplete.

Again, we usually think of the water of a river as flowing down a definite course to the ocean. Such an idea, however, is inaccurate, as appears at once if we stop and think that many rivers change their courses, often with great suddenness, as happens from time to time in the Hwang-ho of China. Again, as the water of many rivers in deserts, or on sandy plains, dries up or disappears in the sand long before the level of the sea is reached, it is very incorrect to think that all rivers flow into the sea. They flow *toward* the ocean—that is, down hill—and were

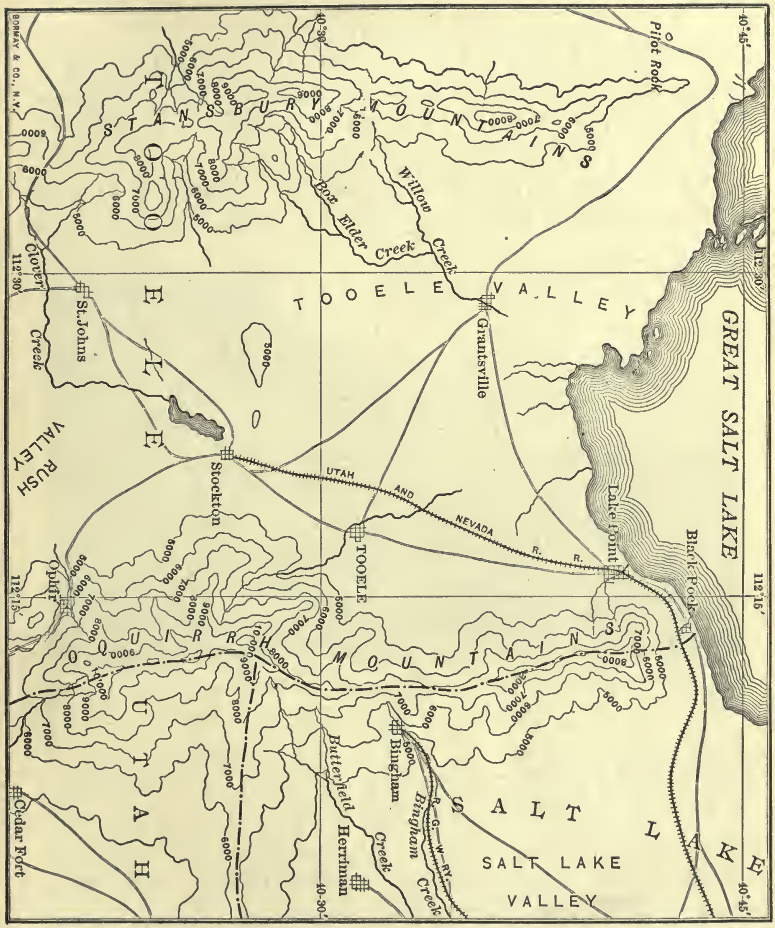

FIG. 37.—MAP OF STREAMS THAT FLOW FROM MOUNTAINS *TOWARD* A LARGE LAKE, BUT DRY UP BEFORE THEY REACH IT.

they able to continue on their way would undoubtedly reach their goal. (See Fig. 37.)

We may describe a river, then, as a stream of water and detritus, flowing toward the ocean. This definition tells the whole truth, and allows all rivers to be grouped together, without giving any false ideas.

The Deposits of Running Water. Alluvial Plains. —The materials thus dropped by a stream when it finds

FIG. 38.—A VERMONT STREAM THAT IS UNDERCUTTING ITS BANK. CONTRAST SLOPES ON OPPOSITE SIDES OF STREAM.

itself overloaded are left in very definite forms. At first the winding river drops some of its load on the inside as it turns a corner, and rushing more swiftly on the outside cuts a deeper channel, and perhaps undercuts the sides of the channel, leaving a steep bank. (See Figs. 38 and 39.) The country boy living near a stream knows the deep part of the stream as his swimming pool, the sandy or gravelly slope on the inside of the curve as his out-of-door bath-house, and the steep bank, perhaps, as a diving board.

Gradually, by this process of dropping the larger particles of its load, the river succeeds in building up a large flat plain along the sides of its course between the steeper walls of the side and the channel. This plain, being made of more or less fine material, is usually good farm land, and in narrow, deep valleys is the place where railroads and roads are built. Such flat plains of greater or less

FIG. 39.—A DRY STREAM BED, SHOWING CURVES AND SLOPES OF STREAM. NOTICE ALSO IRRIGATION DITCH ON THE SIDE OF THE RIDGE.

size along most rivers are known as *alluvial plains*, and may be seen in miniature in the wayside mud puddle. (See Fig. 40.)

Some of the great alluvial plains of our greater rivers form the richest farming land that can be desired. The alluvial plain of the Mississippi, that extends from the mouth of the Ohio River to the Gulf of Mexico, and through which the great river wanders, or meanders, in a very crooked course, is a wonderfully rich farming region, devoted largely, at least in its more southerly part,

to cotton and sugar-cane. (See Fig. 9.) Such alluvial plains are not, however, perfectly flat, and do not, as a rule, slope from the sides of the valley to the stream, but from the stream toward the sides of the valley. Thus the parts of the plain back from the stream are often not so high as the banks of the river, especially when the banks have been made higher by the building of levees, as along the lower course of the Mississippi. Hence

FIG. 40.—AN ALLUVIAL PLAIN IN IRELAND. NOTE THE CROOKED COURSE OF THE STREAM AND THE WALL MARKING THE HAY FIELD.

these regions are often more or less swampy, and are subject to overflow when the river is in flood. It is the lower portions of the alluvial plain of the Mississippi that are often covered to great depths in freshets, causing a large loss of life and property. On the Donaldsonville sheet of the United States Geological Survey map of Louisiana the houses are all shown as being close to the river, and the swampy area away from the river is crossed by streams that start within less than a quarter of a mile

of the Mississippi, and flow away from it. (See Fig. 41.) The great Yazoo River follows such a course in a marked way, flowing in the lower depression between the Mississippi River and the bluffs bounding the alluvial plain to the east, until finally the Mississippi River, swinging to

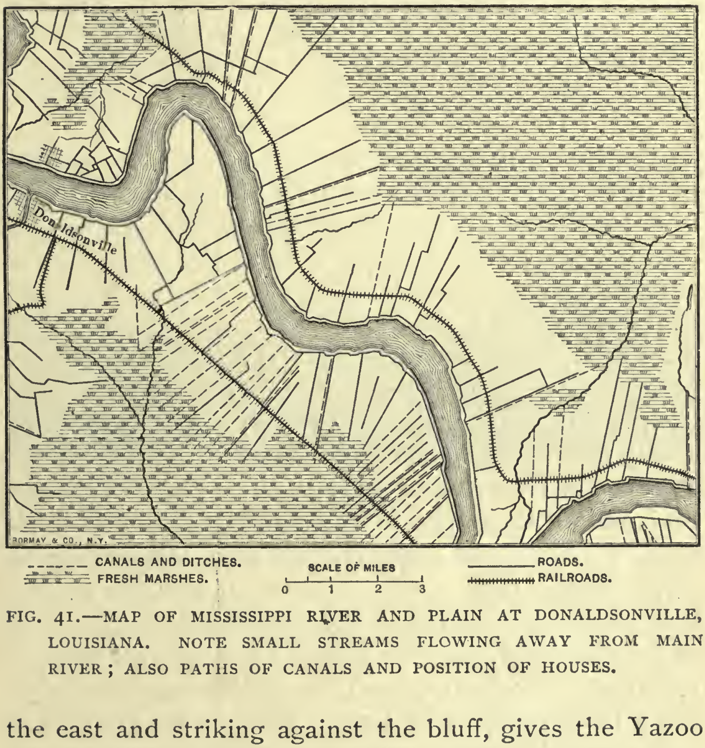

FIG. 41.—MAP OF MISSISSIPPI RIVER AND PLAIN AT DONALDSONVILLE, LOUISIANA. NOTE SMALL STREAMS FLOWING AWAY FROM MAIN RIVER; ALSO PATHS OF CANALS AND POSITION OF HOUSES.

the east and striking against the bluff, gives the Yazoo River a chance to enter the main stream. Close to this point, where the river comes against the bluff, is the city of Vicksburg, Mississippi, on the bluff. Natchez, Mississippi, and Memphis, Tennessee, are other illustrations of large cities safely placed on bluffs, but close to the

Mississippi River and to the rich land of its alluvial plain. Such a position is the wisest and safest, and hence is very frequently chosen. As large towns in great alluvial plains are exceptions, we may say that the bluff location is the rule.

Alluvial Fans.—Such river-made plains as have been described are the characteristic forms in which overloaded rivers lay down their extra burden as the decreasing down-stream slope causes their ability to carry the load to weaken. The forms in which the load is deposited when a river course changes *suddenly* from a steep slope to a gentle slope, or when a river runs into a standing body of water, are no less important, and in some cases more interesting. In the first place, since the slope changes abruptly, the power of the stream to do its work is suddenly decreased; it cannot stop to drop its load a little at a time, but must drop most of it at once. Such sudden changes of slope occur usually where tributary streams from a side valley with steep slopes run into the more gently flowing main or master stream; or where short, swift streams from mountains run across plains or through lowlands on their way to the sea. Under such conditions we often find deposits known as *fans*, which are really great conical heaps of material, with the point of the cone in the mouth of the depositing tributary river and the base of the cone creeping out over the adjacent lowland. The form is such as would be made by opening a fan out flat, and then curving it by pressing up under the middle sticks and down along the outer sticks. (See Figs. 42 and 70.) Fans of small size may be seen in almost any ploughed field or sand-bank after a heavy rain. Were the material dumped by the river in open country, and not piled up on the side of the valley, the

detritus would accumulate in a perfect cone, such as one can sometimes see in coal yards where the coal is dumped in the centre of an open space from an elevator, or in the piles of sand beneath the screen where masons are screening sand for mortar.

In such cases it is seen that much of the material poured on the top usually runs to the very bottom of the slope, thus building the cone forward as it grows upward. In a similar way in the river-made half-cones or fans, the fan

FIG. 42.—PROFILE OF A LARGE ALLUVIAL FAN IN UTAH. THE DEPOSITING RIVER FLOWS FROM RIGHT TO LEFT.

builds forward as it grows upward. Above are the sharp-sided, narrow ravines made by the swift-running water, and at the foot of the steep slope are the many fans of various sizes and slopes, coarse materials building up steep fans, and fine materials more gently sloping fans. Sometimes the fans are so numerous along the face of a steep cliff or bluff that they finally meet, thus forming a continuous slope of detritus, like a talus with a gentle slope.

Alluvial fans are important and interesting for other reasons than because of their shape and origin. They

are often topographic forms of great use to man, the great fan of the Hwang-ho in China, one of the largest known, being one of the most densely populated regions on the globe. This example is noteworthy also, because it occasionally illustrates the fact that rivers crossing fans may flow down the slope in any direction with almost equal ease. If a river flowing on a fan changes its course suddenly, as the Hwang-ho has a way of doing from time to time, destruction must follow. We can often illustrate this process in a wayside stream by putting a pebble or a handful of earth in the channel occupied by the stream, thus changing its course at once. In many cases in mountainous regions, as the Alps, the fans are the most fertile land, and are the seats of the villages and the best fields. Occasionally small fans, being made of materials a little coarser in character than the adjacent lowlands, are occupied by the houses and farm buildings, while the better land of the lowlands is given over to cultivation. Examples might also be given where alluvial fans form naturally graded roads up into steep-sided valleys, which are used as highways. Thus their uses are many and their importance great. They might be called open-air deltas, as their form is similar to those deposits which we call deltas, made where rivers run into standing bodies of water, such as a lake or the ocean.

Deltas.—If we watch a small stream running down a hillside in a rainstorm, and flowing into a small mud puddle, we shall see that the water is thick and yellow with the load it is carrying. After the rain has ceased, and the mud puddle dried up, we shall find in the bottom of the little hollow a flat-topped pile of sand and mud extending from the shore into the deeper part of the puddle. Such a delta shows us in miniature the

more important features of the famous large deltas of such rivers as the Mississippi and the Nile. If we look carefully at the front of the delta, we shall find it irregular and somewhat scalloped in outline, bounded by a somewhat steep slope, and curving forward into the puddle wherever a small branch of the main stream has brought down and dumped an accumulation of materials. Perhaps we may be able to see the small channels running across the delta and branching from the former mouth of the main stream as the ribs of an oak or maple leaf branch from the main stem. Such channels, common to deltas as they are to alluvial fans, show us that the main stream is divided at the head of the delta into a number of branches, each doing the same kind of work, and each depositing its share of load at the front of the delta.

Streams running toward the main or master stream in the river valley have been called *tributaries*, because they *contribute* water and detritus to the main trunk stream. In the same way, streams flowing away from the master stream, as they do in deltas, and distributing the load and the water in several different directions, may be called *distributaries*. If we look at a whole river system, we shall find that the tributaries run toward one another and join the main trunk, as the leaves of a corn-stalk join the main stalk; the distributaries run away from the main trunk, as the roots of the corn branch from the main stalk. In the corn-stalk much of the water received is carried down and distributed around the roots; a similar distribution occurs in the case of a river.

When deltas grow up to the surface of the water, they of course become land, and their rivers continue across them to their outer edge, thus changing the shape of the

shore line and extending the river valleys. (See Fig. 43.) This land usually being formed of fine soil, such as is found in the alluvial plain, is naturally very rich, and, like the alluvial plain, may thus be of very great importance in agriculture. This is particularly well illustrated in the delta of the Nile, which is famous for its abundant crops of rice and sugar-cane. Sometimes, however, the growth of a delta at the mouth of a stream, particularly of a large stream like the Mississippi, is embarrassing, because no one of the distributing branches keeps its channel deep enough to allow the entrance of large vessels. In such cases commerce can be carried on only after the channel has been deepened at great expense and with great effort. This has been done in the case of the Mississippi, so that now ocean vessels go up the river over one hundred miles to New Orleans.

FIG. 43.—MAP OF MISSISSIPPI DELTA. NOTE THE ARRANGEMENT OF DISTRIBUTARIES, NUMBER OF MOUTHS, AND RELATION OF COMMERCE TO RIVER.

Rapids and Waterfalls.—We have spoken thus far as though a stream flowed from source to mouth without any interruption, and as though it might cut down its channel toward the level of the sea without being hindered in its work by any features of the earth itself. Such is not the case, however; for if we follow down any small stream, and many large ones, we find that the rate of flow is sometimes rapid and sometimes slow. For

instance, if we should study the Bronx River as it flows through Bronx Park in New York City, we should find in the upper course a slow, sluggish, crooked stream, flowing through a small alluvial plain; at the lower end of the alluvial plain we suddenly enter a deep, rocky gorge, through which the river flows rapidly and in a rather straight course. The rapids are formed in this river, as in all rivers, wherever there is any barrier that prevents the river from wearing there as rapidly as it can up or down stream. Such a barrier is very frequently a layer of strong rock that crosses the stream, and through which the river must saw its way. As the running water must flow down hill to reach the sea, no part of the course up stream can be worn lower than the edge of the down-stream barrier that causes the rapid or fall. As the barrier is cut down, however, the up-stream valley can be lowered to correspond with this lower level. For instance, the valley up stream from Niagara Falls cannot be worn down any lower than the falls, for water must have a slope to run on. Niagara is, however, being slowly worn down, and just as slowly Lake Erie is being drained of its water.

Sometimes above the barrier we find a lake, sometimes an alluvial plain, or a flat valley that may be used for agricultural purposes. In any case, the stream may be divided into what may be called, in the language of the camper and canoer, rapids and reaches. In the reaches canoeing may be possible, as the current is slow; where there is a rapid or a fall, canoeing is usually impossible, and the traveller must carry his boat and his equipment around the obstruction. Hence at such places we have a so-called *portage*, or a *carry*.

Rapids indicate the place where usually the water may

be made to accumulate by building a dam, in order that a supply may be secured which will be available in dry times as well as immediately after rains. If we examine the location of the large manufacturing towns of New England, we shall find a great many of them located at or near the fall of some large river, which gave them water for power and made their growth possible. Where the stream is large and clear, and the fall high, we may have an object of scenic interest famous for its beauty. For instance, at Niagara Falls the water leaps over a precipice 160 feet high, making a wonderful spectacle known the world over.

Results of Work of Running Water.—If the processes of atmospheric and river erosion continue for any great length of time, there must, of course, be a great change, not only in the shape of the land surface, but in its height above the level of the sea. We cannot continually remove materials from a place without lessening the quantity there. Hence the lands of the world must be gradually lowering, and the highlands must be growing less high, under the attacks of the forces we have considered. Or, as we may say, the lands grow *old*, become worn down more nearly to the level of the sea, being then less rugged, with large streams flowing slowly and smoothly through them.

As the river is the main route whereby the detritus of the land can be carried to its goal in the sea, it is impossible for the lands to be worn down perfectly flat; there must always be a gentle down-hill slope, so that the water will run off. As time goes on, however, the peaks and divides between adjacent streams become less and less sharp, and the slopes more and more gentle. It should be noted, however, that when the land is low

there is no more land draining its water to the sea than there was when the land was high; it may, however, be drained much more quickly after a rain, owing to the removal of the barriers of the lakes which formerly held the water back.

CHAPTER X.

THE WORK OF STANDING WATER.

Kinds of Standing Water.—We have already suggested that a large part of the water of the world stands more or less quietly in lakes or in the ocean, and in the associated seas, bays, and gulfs. Were it not for the forces that set the surface of the water in motion, standing water would be of little importance as an agent of erosion, for it would lack power of delivering blows on the land. Any of us who are familiar with the beach, however, know that standing water is rarely quiet, except, perhaps, in a summer calm; motion of some sort being almost continuous, the work accomplished must be important. Standing water may be in motion in any one of three ways, as surface waves, as continuous currents, or as intermittent tides. If we blow steadily on a small pan of water we set its surface in ripples, which will swash against the side of the pan, and rise and fall as do waves; if we blow constantly at one spot, we shall finally set a large part of the water in motion around the pan, or we shall start currents. Tides cannot be so easily illustrated by experiment.

Each of these three motions can do work, but as that work is mostly confined to the surface of the water, it is the coast rather than the bottom of the sea or lake that is eroded. As the water stands at a nearly constant level, the marks made by the water work must be nearly at the same height, so that water cuts horizontally rather than

vertically. Here is the great distinction between the work of standing water and running water. Running water makes a country rough, with more or less steep and irregular slopes; standing water tends to cut great horizontal benches in the land, with bluffs above, giving a very regular form of topography, made up of few slopes. Let us study these three forms of motion, and see the results of their work.

Wave Erosion.—The most conspicuous and important of these three forms of work is that done by the waves. We are, perhaps, familiar with the small waves raised on the leeward side of a river, which continually slap up against the land with a little swish, perhaps rolling a few pebbles on the shore back and forth; we see the water roll in, we see it fall or break, and then comes the sheet of water made by the falling wave, which runs up the shore, if the shore be gentle, for a considerable distance. The little pebbles are rattled together, and are borne first up the shore, and then down, as the waves run in and out. If we go to the ocean in a time of storm, and particularly to a sandy shore, we shall see the same process, only on a larger scale. (See Fig. 44.) The waves will roll in in great size, nine or ten times a minute, and will thunder down on the shore, and rise up perhaps in spray. We may be able to feel the jar of the waves as they fall, and appreciate the fact that the earth has been dealt a great blow that has made it quiver. As the wave slides up the beach toward our feet in a thin sheet of foaming water, we may hear the crackle of the little pebbles as they are rattled together; as the wave runs back to meet the next, we can see the pebbles running down the shore, and can hear the fainter crackle, and see that the water is muddy with the material it is carrying.

The finer mud will probably be carried slowly out into deep water, and there quietly deposited.

Thus in the falling and advancing wave there is the same work of erosion, the same carrying of a load, the same preparation of material for final deposition in the sea, that we saw in the case of running water. If we exam-

FIG. 44.—BREAKING WAVES ON A NEW JERSEY COAST. NOTE THE BREAKING WAVE, AND THE SHEET OF WATER FORMED FROM PRECEDING WAVE.

ine one of the pebbles we shall find it well rounded, with every mark of having been recently shaped. Its surface will not be at all weathered. This is the natural process of rock-rounding which is utilized in the making of marbles, where the regular blocks of material are turned in a rotating cylinder, until finally they have had all their corners knocked off.

In some cases we can experience the active pull of the

waves in carrying materials toward the sea, by standing in shallow water, and allowing the waves to run in and out around our feet. We may feel a strong rush of the water close to the ocean bottom, and realize that the materials are being carried away from around our feet, so that it seems as if we should be undermined. This pull of the waters as the wave runs back to the ocean is known

FIG. 45.—SEA CAVES AT LA JOLLA, CALIFORNIA.

as the *undertow*, and is a very important part of the wave work, for the detritus worn from the land is carried to its long resting-place in the sea largely by this process.

The place to see the waves at work with their greatest force is perhaps on a rocky shore, where they thunder in against the base of a great cliff, slowly sawing horizontally into the rock mass. In such a case, as along many parts of the coast of Maine and California, we find at the

foot of the cliff, and at the level of high tide, a little cave cut into the cliff itself. (See Fig. 45.) The cave may be exposed and left dry when the tide is out. From their likeness and shape to the old-fashioned tin or Dutch oven, that was placed in front of a wood fire with the open side toward the fire, such caves are known in Maine as *ovens*. When the cave has been cut back so that the overlying rock is no longer supported by the under rock, it falls into the sea, thus feeding the waves with new materials to be worn out and carried away.

Usually on a rocky shore all parts of the land are not of equal strength. Then naturally the waves cut more actively and effectively on the weaker parts, cutting them back as bays, and allowing the strong portions to remain projecting into the sea as headlands that receive the blows of the water with the least damage. (See Fig. 46.) Thus we have an irregular shore line made, with possibly deep bays that make good harbors. The headlands being high, and projecting into the sea, are dangerous to navigation, so that sailors must be warned of their presence. Hence we expect lighthouses of high power to be placed at such spots on the shore, as we see on the Island of Grand Manan. They warn the passing mariner to keep away from shore, and when near a harbor show the entrance into it, as in the case of the Navesink Lights at the entrance to New York Harbor. Dangerous rocky shoals made by the incomplete cutting down of a headland are also marked by such a beacon, as at Minot's Ledge in Boston Harbor, or at Eddystone Rocks in the English Channel.

Sometimes the weaker rocks are worn back by the waves, and long, deep chasms are formed, into which the water rushes with tremendous force and with great noise.

Occasionally part of the roof of such a chasm falls in, making a hole through which the water may be spouted at high tide, giving us a so-called spouting horn, of which there are excellent examples at Newport, Rhode Island, and Marblehead Neck, Massachusetts.

Wave Deposits.—The materials removed from the

FIG. 46.—A HEADLAND IN ENGLAND, WITH A SEA CAVE IN PROCESS OF FORMATION.

land, and particularly from the headlands, are carried along shore, and in part deposited in the bays in what are known as beaches. Sometimes the headlands are so near together that the beaches are like little pockets in which the sand and gravels accumulate, and are then known as pocket beaches. (See Fig. 47.) If we pass from the headlands toward the centre of such a beach, we shall usually find the pebbles growing finer and finer, as

we get farther from the sources of supply. If the headland on one side of the beach is made of one kind of rock, and that on the other of another, we may find most of the materials of the beach like the nearest headland.

Where the land is of uniform strength, the waves have little opportunity of carving it into headlands and bays and we are apt to find long, straight sand-beaches,

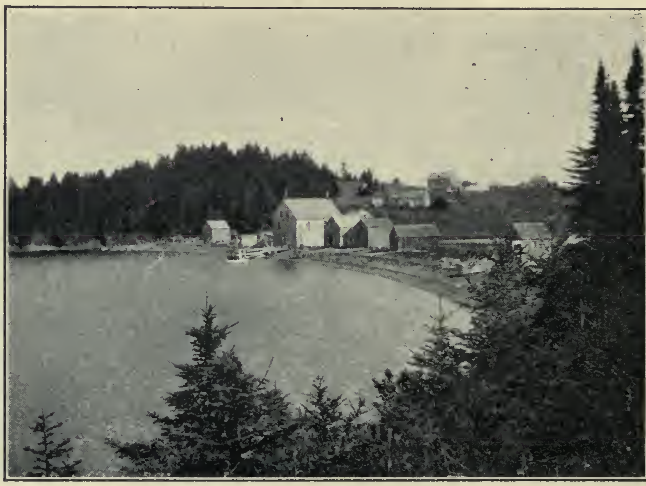

FIG. 47.—A POCKET BEACH IN MAINE, USED AS A FISHERMAN'S LANDING.

such as those along the New Jersey and Long Island shores, which extend for miles with few interruptions. They are made of the materials brought in part from the land, and in part from the bottom of the sea as the waves have rolled them in. Sometimes we find such long beaches formed quite a distance offshore, and not connected with the mainland except at one end. Such beaches were once offshore bars, formed where the waves first broke. Finally they grew above the level of the sea.

In such a case there exists between the offshore beach and the coast line a lagoon of more or less quiet water, with an outlet to the sea, such as we have on the south side of Long Island, in Great South Bay, inside of the barrier beach known as Fire Island Beach, and at Sandy Hook, New Jersey. (See Fig. 48.) The waters of the bay are shallow and usually quiet, and form excellent yachting grounds, and fishing grounds for oysters and clams. The barrier beach, as in the case of most of the beaches of New Jersey, being, as it were, out in the sea, is an excellent place for a summer resort, as there will be a water breeze,

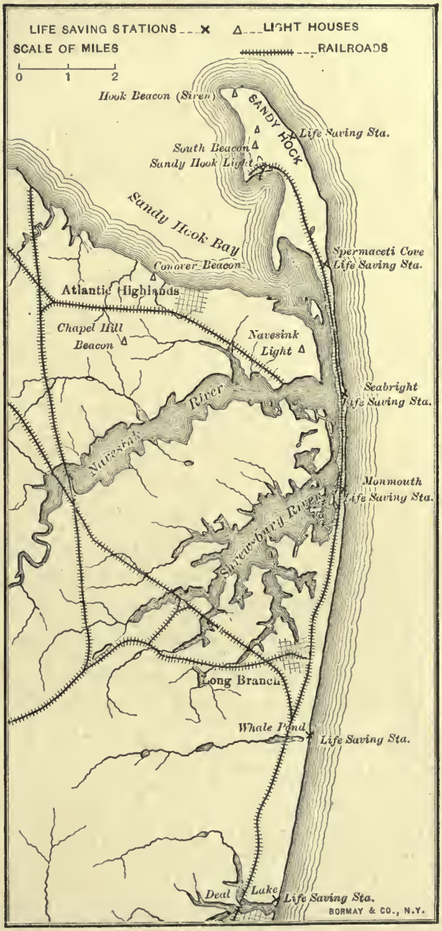

FIG. 48.—MAP OF SANDY HOOK, NEW JERSEY, SHOWING A BARRIER BEACH ENDING IN A HOOKED SPIT. NOTE HOW HARBOR IS FORMED, AND POSITION OF LIGHTHOUSES AND LIFE-SAVING STATIONS.

no matter from what direction the wind blows. Such sandy, regular beaches have but few large indentations suitable for harbors, as we can see by studying the coast line of New Jersey from New York southward. Hence they cannot be the seat of many large commercial centres.

Harbors will occur wherever, through a sinking of the land, the salt water has been allowed to enter the submerged or drowned river valley, forming a good estuary, as in the case of the Hudson River and Delaware Bay. Any sandy beach near a large city, such as Coney Island, is a good place for a summer centre of life, though the winds blow from the sea but a part of the time.

Small, short beaches are also frequently formed between an island and the mainland, where the waves, rolling in together from opposite sides of the island, meet and lose their carrying power. If such a beach grows to the surface of the water, the island will be tied to the mainland or to another island, and we may have an isthmus and a peninsula; if the beach be removed, the peninsula will again be changed into an island. Such island tying and untying is a common result of ocean work.

Ocean Currents.—The second way in which standing water is set in motion is in the form of ocean currents, as we have already noted. At the centre of the great oceans, as, for instance, in the North Atlantic, the water is practically quiet, and often so filled with plant life that navigation is somewhat difficult, as was discovered by Columbus in his first voyage. About such a quiet centre there is a very systematic circling of the waters in a slow and steady course. If one should stand in the centre of either northern ocean, the waters of the edges of the ocean would be drifting about him as the hands of a clock or watch move about the centre, from left to right; if one

should stand in a similar position in the centre of either of the great southern oceans, the water would drift about him in the opposite direction, from right to left.

Such ocean currents are very frequently spoken of as streams; but the word *stream* is more truthfully applied to a narrow and special current of water flowing with considerable force through slower moving water on either side, as the Gulf Stream, which flows at a rate of 80 or 90 miles a day out from the Gulf of Mexico, and north-eastward across the North Atlantic. This stream is, however, but a small part of the great system of moving waters of the North Atlantic, which may very well be called the North Atlantic Drift, the word *drift* suggesting very well the easy-going rate at which the water progresses.

As the currents move generally from warm regions to cold on the western sides of the oceans, and from cold regions to warm on the eastern sides, the ocean waters in most regions are colder or warmer than the average temperatures of the adjoining lands. As the winds move over the oceans the air becomes warmed or chilled by the water beneath. When the winds blow from a warm ocean to a cool land, as in the winter they blow from the North Atlantic upon the shores of Europe, the lands they reach become warmer than other lands in the same latitude. In the same way winds blowing over cool currents become chilled and carry low temperatures with them. It is not, therefore, the drifting of ocean currents upon a shore that changes the temperature of the land, but the drifting of wind that has been warmed or cooled by blowing over the currents. It is because of this effect of the currents upon the accompanying winds, that the continents on the eastern side of an ocean may be occupied to much higher latitudes

than on the western, as is seen by comparing the position of the great English nation on the British Isles, on the eastern side of the North Atlantic, with the desolate and uninhabited coast of Labrador, at the same distance from the equator on the western side of the same ocean.

There are many smaller and subordinate ocean currents besides the systematic drifts mentioned; but their effects are not very important, though perhaps mention should be made of the cold Labrador current that chills the northeastern United States, as it creeps down along the Labrador and Maine coasts until it meets with and disappears beneath the warmer waters of the Gulf Stream. Along the border where these currents first come together we have the famous fog banks of Newfoundland. (See Fig. 49.)

The ocean currents, running largely along shore, do but little work in wearing away the continent, as their force cannot be applied directly to the continent, as can the force of the waves. In some cases, however, the ocean currents, sweeping by the mouth of a great river, may scatter the detritus brought down by the river far and wide over the neighboring ocean floor, thus preventing the building of a delta. It is largely because of such work by currents that we find no large delta in front of the Amazon River.

Next to the work of distributing moisture and temperature, and the detritus brought by rivers, the ocean currents are important because they keep the surface waters of the ocean in motion, thus supplying food to the mouths of the animals and plants that live attached to the ocean floor, and are dependent upon having their food brought to them. It has been found, for instance, that where the other conditions are favorable, corals grow

most rapidly where there is a strong ocean current that provides abundant food.

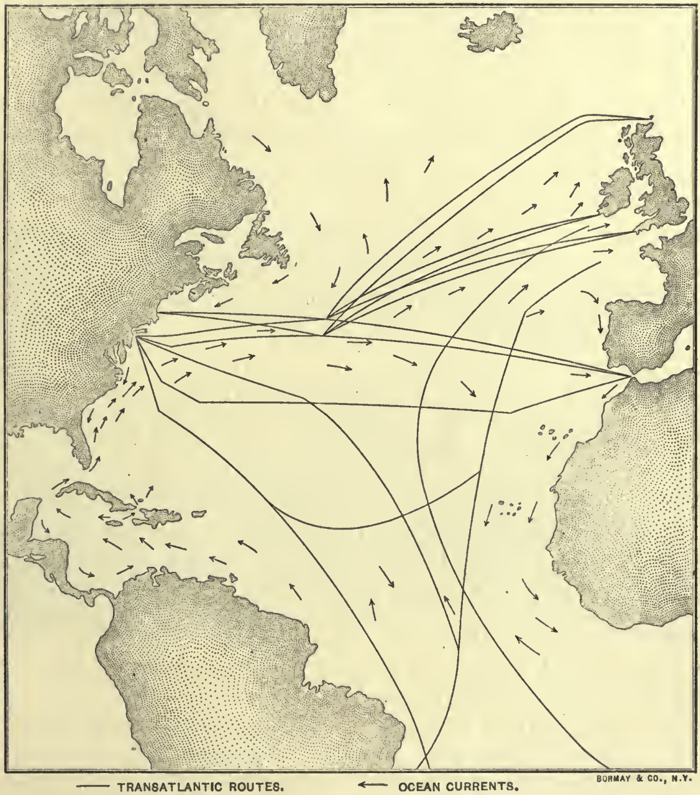

FIG. 49.—MAP OF PRINCIPAL OCEAN CURRENTS AND OCEAN ROUTES OF NORTH ATLANTIC OCEAN.

Tides.—The third and last kind of motion of standing water, best seen in the oceans, but also to be found in large lakes, is that known as the tide, which is due to a

complicated series of causes too difficult for study by beginners. In general, it may be said that the pull of the sun and moon causes tides, the waters of the oceans and lakes being continually heaped up beneath the moon. We should therefore expect high tide at New York City when the moon was directly in the south. When the moon is directly opposite us on the other side of the world, we have another high tide; and when it is half-way between these two points at either side, we have low tide. The difference in height between the level of the waters at high tide and low tide off Governor's Island, New York City, averages 4.5 feet; at New London, Connecticut, there is a difference of but one foot; and at Boston, Massachusetts, the range of height is from eight to ten feet. In the Bay of Fundy, where the tides are famous for their work and strength, there is a range in height of something over fifty feet. This variation in height is largely due to the character of the coast line against which the water comes.

Where the water of the tide goes in and out through the mouth of a great estuary twice a day in either direction, it rushes with tremendous force, and may do a large amount of erosive work, keeping the channel scoured clean, and preventing any deposition of the detritus brought by the rivers and waves. This tidal scour is very important in keeping many harbors clear and usable. Indeed, the principle is used at the mouths of many rivers, as, for instance, in the case of the Mississippi, where the water is forced by a series of jetties to follow a narrow channel, thus keeping the bed of the stream from filling up with fine mud or silt.

Although the tidal scour is important in keeping the harbors from filling up, and thereby of great value to

such a city as New York, yet in some ways the tide is a hindrance to commerce. For instance, sailing-vessels find it difficult to make any headway against a strong tide, particularly if the wind be light. In a similar way our great ocean steamers, owing to their draught, and

FIG. 50.—A LAKE FORMED BY A NATURAL BARRIER BUILT ACROSS A SMALL STREAM IN NEW HAMPSHIRE. THE LAKE IS SHOWN AS FROZEN INTO AN ICE PLAIN.

the need of deep water, find it necessary to pass in and out of New York Harbor on the incoming or flood tide, rather than on the outgoing or ebb tide.

Lakes.—The bodies of standing water held up stream by some rock barrier across a river's course, and known as lakes, present many features in common with the larger oceans. (See Fig. 50.) The work of waves may

produce extensive changes on the shore line, and give us topographic forms very similar to those to be seen on ocean shores. If for any reason the lake disappears, the shore lines, the cut cliffs, and benches may be left on the hillsides as witnesses to the former presence of water. This is well illustrated in many places in New York about the south shore of Lake Ontario, and also about

FIG. 51.—BEACHES AND CLIFFS NEAR SALT LAKE CITY, UTAH, AND HIGH ABOVE THE PRESENT LEVEL OF GREAT SALT LAKE.

Great Salt Lake in Utah, which was once a lake many times its present size, and several hundred feet deeper. (See Fig. 51.)

The lakes which are very frequently found above a waterfall, as in the case of Lake Erie, up stream from Niagara, are often of great importance to man. They may serve as natural reservoirs, holding the water back so that it does not run all at once to the sea after a rain,

thus giving a supply of water that may be used for drinking water by large cities, or for manufacturing purposes. The shore of a large lake offers a very favorable situation for summer homes (see Fig. 50) and camping places, because of the fresh, cool air, the beauty of the scene, and perhaps the fishing, all of which assist in making a lake a pleasant spot near which to live.

The series of great lakes along the northern border of the United States offers a means of communication by water that reduces greatly the cost of transporting goods that are not perishable from the interior to the ocean ports. As water does not warm so rapidly in the summer, or cool so rapidly in the winter as land, large lakes tend to make the climate round about them more uniform. At the eastern end of Lake Ontario, for instance, where the winds blow for a greater part of the year from the lake, the temperature is much more uniform than in the adjacent highlands of New York State, which have much colder winters. As the wind blows from the lake, it gathers moisture, forming mists or clouds, so that the region spoken of has many more cloudy days in the year than can be found in any other part of the State, except round about New York City, where moisture in a similar way blows in from the sea.

Finally, lakes are important because they allow the detritus brought to them by the streams to settle, so that the outgoing streams are clear. The River St. Lawrence, as it flows from Lake Ontario through the Thousand Islands, is such a beautifully clear stream, carrying but little detritus. The River Rhone, as it flows into Lake Geneva in Switzerland, is a milk-white stream, full of fine ground rock gathered from the glaciers; and this is accumulating as a delta at the head of the lake. When

the River Rhone emerges from Lake Geneva, it is one of the clearest, most crystal rivers in the world, because its fine silt has been dropped in the lake.

Whenever a lake bottom is revealed by the filling or drying of the lake, or by the removal of the barrier that held the water in, the fine muds of the bottom of the lake are exposed as a level plain, very rich and very flat. (See Fig. 52.) In Manitoba and North Dakota a great lake floor has been recently exposed, and in the soils of this old lake floor are raised the greatest wheat crops of

FIG. 52.—AN EXPOSED LAKE BOTTOM ABOUT GREAT SALT LAKE, UTAH.

the United States, and among the greatest in the world. (See Fig. 53.)

Summary.—We have already seen that the general effect of standing water is to cut into the land horizontally, making cliffs and beaches; perhaps making the shore line more irregular where the rocks are of varying strengths, and regular where the waves and currents can build long and unbroken beaches. The area, however, that can be attacked by the waves and tides and ocean currents is small compared to the area of the world that can be worn by the atmosphere and running water. All

parts of the rock surface of the world not covered by vegetation and by ice are subjected to active weathering; and even the area covered by vegetation wears slowly under the attack of the erosive forces we have considered.

The forces of the ocean, however, cannot attack the shore except between the limits of the bottom of the waves and the top of the cliffs reached by the highest spray. More than five hundred feet below sea level there

FIG. 53.—A FIELD OF FLAX ON THE GREAT DAKOTA LAKE FLOOR.

is probably but little water motion and water work; and above a height of one hundred feet there is also but little water work. Thus most of the ocean force is concentrated on the very coast line. The area thus exposed to water work is very narrow, and is as long as the coast line of the world, which is many thousand miles. This area, however, can in no way be compared in size with the greater area attacked by running water and the atmosphere, and thus in a given time we must expect standing

water to be of less importance as an eroding agent than are the other forces.

The great bodies of standing water that we see in the greater oceans and seas are also very important because they are the receptacles into which the running water of the world, and the winds, are carrying all the materials brought from the land. Thus as the land surfaces are wearing down, the oceans are filling up with detritus brought from the land. As the land surfaces become rougher under the attack of the erosive forces, the irregularities of the ocean bottom are becoming more and more covered with the fine muds and sands brought from the land. Were these processes to continue uninterrupted, it would only be a question of time when the land surfaces would be worn beneath the level of the sea. There is, however, another series of forces at work, counteracting these influences, for the continents are continually rising from beneath the sea, and being folded into mountains, presenting thus a new supply of land to the forces that are wearing it away, and making it possible for land life to continue.

CHAPTER XI.

THE WORK OF ICE AND FROST.

THE fourth and last great way in which the surface of the earth is changed in shape is through the work of water in its solid forms—that is, as ice, snow, and frost. In temperate regions, such as ours, the work of snow and frost is ordinarily seen each winter, when we have about us good illustrations of conditions in the so-called frigid zones. On the tops of very high mountains, even in the tropical regions of the world, and around the north and south poles, snow and ice exist continually, melting away a little in the summer, but never disappearing. In such regions, where the work is continual, it is natural to expect that the erosive work of ice must be important.

Effect on Life.—The animals and plants in the temperate region live a life that is more or less arranged to withstand the cold and frost of the winter. Plants cease their growing and perhaps die, the life of the plant remaining over to the next season in the seed, which is not injured by frost; the sap of many trees retires to the roots, and some trees may freeze through without being hurt. Many animals retreat into burrows, or some other retired spot, and rest, or, as we say, hibernate, during the winter, as may be illustrated by the thousands of bats that inhabit Mammoth Cave in Kentucky, or by the flies that may be found sometimes by the handful in unused boxes in country attics. Other animals, such as the ranch cattle, grow thick coats, and

manage to exist in the open weather, feeding on whatever shrubs or roots or seeds are available. Some animals, like the English sparrow, are so hardy that they seem to pay no attention to frost and snow.

Effect on Rocks.—The work of frost and snow is also important in its effect on the rocks of the earth. (See

FIG. 54.—ROCKS ON THE SUMMIT OF PIKES PEAK, COLORADO, BROKEN BY FROST. THE WHITE PATCH IS ICE THAT REMAINS THROUGH THE SUMMER.

Fig. 54.) The farmer knows very well that if he ploughs his land, and turns the deeper and larger soil particles to the surface before winter sets in, the water penetrating into the cracks of the stones will, in freezing, split them in pieces, making it much easier to prepare the soil for planting in the spring. An indirect effect of snow and ice is seen in the frequent and serious spring floods

caused by the sudden melting of the water that has been locked up in a solid form as snow or ice on the hillsides and mountain tops during the long winter season. When the frozen ground melts in the springtime, the soil is full of moisture, and is usually very muddy. If the soil lies on a steep slope, there may be small landslides, produced by the slipping of the soil down hill. Farmers in New England and New York expect to see their stone fences undermined and tumbled down through the work of the spring thaws following the long winter frost, and the Farmers' Almanack for March and April usually includes such advice as, "Now is a good time to repair fences that have been weakened during the winter."

Snow.—Although frost and ice may damage plants and animals to a certain extent, a deep layer of snow lying over the grass roots and around the trees is a great protection, as it keeps the roots from freezing and thawing with each sudden change of temperature. Rabbits and mice may live comfortably in the snow; and frequently, when the snow melts in the springtime, one finds the streets of a mouse city, made by the mice as they have burrowed through the snow on their way to roots and bark that would furnish them food.

Glaciers.—As has been suggested, snow exists in certain parts of the world the year round. As it lies on the land from year to year, it may accumulate in great masses, and under the accumulating pressure of the new layers may be slowly pressed into blue ice, just as a boy makes a solid icy snowball by pressing together fine white snow until the air is pressed out. Such accumulations of ice and snow are known as *glaciers* (see Fig. 55), and are found in Alaska, Greenland, Northwestern Canada, Norway and Sweden, Switzerland, New Zealand,

and certain other parts of the world. The glaciers do not remain on the sides and tops of the mountains where the snow has accumulated, but slowly flow down toward the adjoining lowlands, very much as a mass of heavy pitch or molasses candy would slowly flow down a sloping trough. As a result, glaciers may be found far within

FIG. 55.—THE MARGIN OF THE DAVIDSON GLACIER, ALASKA. NOTE ALSO THE PERPETUAL SNOW ON THE MOUNTAIN TOPS.

the region where the snow does not lie throughout the year, as, for instance, in Switzerland, where the glaciers push down the valleys between the bare hillsides which are miles away from the snow-covered mountains. The glaciers push into the warmer regions, until finally the heat is great enough to melt them back as fast as they push forward. If the melting back is more rapid than the advance of the glacier, the front of the glacier is

pushed farther and farther up stream, or, as it is sometimes stated, the glacier retreats. The water furnished by the melting of the ice forms rivers, sometimes flowing

FIG. 56.—MOUTH OF A STREAM FLOWING FROM BENEATH A GLACIER IN ALASKA.

from under the ice, and always present at the front of a melting ice sheet. (See Fig. 56.)

In some cases the glaciers push directly into the ocean, as in Alaska (see Figs. 55 and 57), and then the great ice mass breaks up into smaller pieces that float away as *icebergs*, until finally they are melted in the warm waters

of the ocean through which they travel. The captains of ocean steamers running between the British Isles or Germany and New York frequently report icebergs during the spring and summer months. Though icebergs move but slowly, they are dangerous objects in the ocean, as they have force enough, owing to their size and weight,

FIG. 57.—MUIR GLACIER, ALASKA, SHOWING MELTING EDGE AND SMALL ICEBERGS. NOTE ROCK ISLAND SURROUNDED BY ICE.

to crush any small object, like a steam vessel, with which they come in contact.

Review.—A glacier, then, is a moving mass of ice and snow, pushing from the region in which it has accumulated, outwards and downwards toward warmer areas. The glacier is not, like a river, confined to any one small channel in a valley, but covers the whole valley to a nearly uniform depth, and consequently affects a large amount of land in its motion. In Greenland practically

the whole island is covered with ice, giving us a great ice plain. In most regions where glaciers occur they are found only on mountain tops and in the radiating valleys. These are known as *valley* or Alpine glaciers. From the study of such Alpine glaciers, Professor Louis Agassiz showed that many of the surface features of Europe and America could have been formed only by the former work of ice. Other people are now as convinced as he was that an ice sheet so large as to be called a *continental* glacier once covered North America as far south as New York. Let us look at some of the facts that led Agassiz and others to this opinion.

Erosive Work of Ice.—An enormous mass of ice such as a continental glacier, moving over the land, must, by its rubbing, produce a great deal of change on the land surface. Picking up the small rock particles that are easily loosened, it scrapes them along in the direction of its motion, grinding them against the rock beneath until the rubbed rock becomes scratched and smooth (see Fig. 58), and the grinder partly or wholly worn away. The general effect is very much like that of a laundress in smoothing a bit of linen; a flat-iron smooths out all the roughnesses, but if there be a particle of dirt on the flat-iron there will be a scratch or a streak running in the direction of motion, and leaving a slight depression below the general smooth level of the linen. This grinding work of the ice is very important, because all the surface over which the ice glides offers small tools for the ice to use as grinders. As the rock material thus acquired is rubbed and rolled along by the ice, it must of necessity be ground finer and finer, or, as we sometimes say, made into "rock flour," just as corn or wheat in a mill is made finer the longer it is ground. Such fine rock flour gives the milky

color to the streams that flow from beneath glaciers, as has been noted in reference to the River Rhone.

In some cases the ice cannot grind down all the irregularities of the land surface, but, moving around a great mass of rock, may pluck it out and bear it along as a

FIG. 58.—A GLACIALLY SCRATCHED AND SMOOTHED SURFACE AT MARBLEHEAD, MASSACHUSETTS.

tremendous boulder; so that fine and coarse materials are mixed in a confused mass, all going forward together. As the glacier may get its materials from any spot up stream, there is naturally a great variety of particles in the detritus that is being carried along.

Transportation Work of Ice.—The material thus eroded from the land becomes a load for the ice to push

or carry forward. This is not, however, the only source of load, for the glacier gets also a large contribution of materials from any land that may project above the ice, from which avalanches and landslides are very liable to

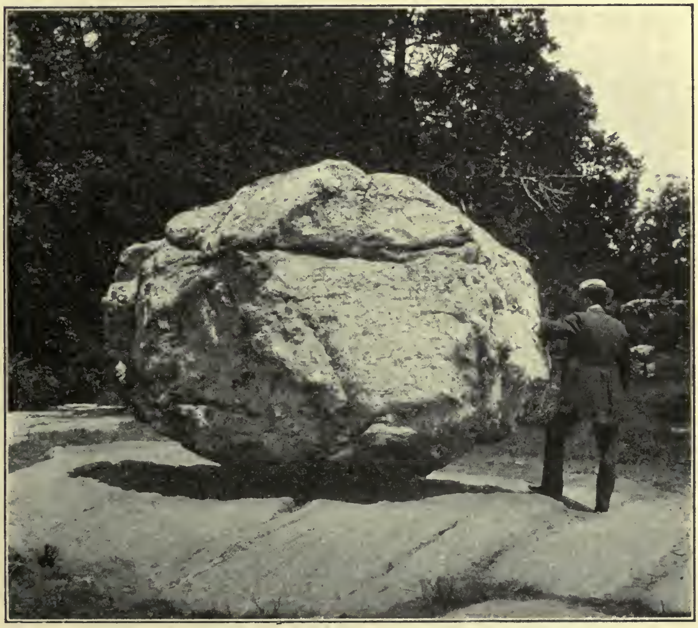

FIG. 59.—THE ROCKING STONE IN THE NEW YORK ZOÖLOGICAL PARK. THE STONE RESTS ON A SCRATCHED SURFACE.

dump materials on the ice at almost any time. Like running water and standing water, glaciers carry their loads as long as their strength will permit.

Deposits Made by Ice.—The deposits of detritus formed by the ice may be made in some cases beneath the ice, and in some cases in front or at the side of the

ice mass. As the ice melts away, of course these particles slowly settle, until finally, the prop which has held them up being gradually removed, they come to rest on the solid rock bottom, without any perceptible jar. Large boulders are very frequently deposited in this manner, perhaps on the top of a good-sized hill, and in

FIG. 60.—A BOULDER MORAINE IN RHODE ISLAND.

such a position that they may be rocked to and fro, but not overturned. The famous Rocking Stone of the New York Zoölogical Park is an excellent illustration of such a boulder. (See Fig. 59.)

The mixed-up accumulations of mud, clay, boulders, etc., dumped in an irregular confused heap, where the ice retreats from the sides of the valley, or where it melts at its front, are known as *moraines*. When first

formed they are very rough and irregular, perfectly barren of vegetation, and covered over with large and small boulders (see Fig. 60), and perhaps dotted with innumerable lakes that lie in the hollows. Such are the features of the moraines now being formed in Alaska, and except for the presence of vegetation which has recently formed,

FIG. 61.—AN ACCUMULATION OF TILL NEAR ST. PAUL, MINNESOTA. NOTE VARYING SIZE OF PARTICLES AND UNDERLYING SOLID ROCK.

such are the features of those parts of the United States, particularly Marthas Vineyard, Nantucket, Long Island, and Staten Island, that are moraines formed by the great glacier that once covered this part of the country. The materials of such moraines are known as *till*. (See Fig. 61.) The soil is very rich, because of its variety of contents; but it is hard to cultivate, owing to the great

number of large boulders that may cover it. (See Fig. 62.)

In some cases the till was apparently overridden by the advancing ice, very much as the snow in front of a snow-pusher may suddenly be overridden and smoothed and

FIG. 62.—A GLACIATED FIELD IN IRELAND. MANY OF THE BOULDERS HAVE BEEN REMOVED IN BUILDING THE HOUSE.

shaped by the pusher, so that, instead of irregular till hills, we have smoothed and symmetrical hills. In Western and Central New York, in Massachusetts, and in Wisconsin particularly there are great numbers of such regular hills, commonly known as *drumlins* (see Fig. 63), and having very much the shape of half a foot-ball. Their longest dimension usually runs in the direction of the ice

motion, as shown by their being parallel to the ice scratches which may be found on the solid rock in their vicinity.

All the material worn away from the earth and carried forward by the ice is not, however, necessarily deposited by the ice itself. The melting ice of the glacier furnishes much water, which may run on the surface as streams, until finally it goes through some crack and disappears to join the stream of water which is flowing beneath the glacier. (See Fig. 56.) Such streams, which accompany

FIG. 63.—A DRUMLIN IN MASSACHUSETTS. THIS DRUMLIN IS BEING WORN AWAY BY THE OCEAN AT THE LEFT END.

all glaciers, and which must have been very numerous along the front of the great glacier that once covered North America, carry forward a great quantity of detritus in their grasp. The water of the streams, while it is flowing beneath the ice, being under the pressure of the mass of ice above, very much as the water in a street hydrant is pressed by the weight of water in a distant reservoir and pipes, often bursts from the front of the glacier with tremendous force, making perhaps great ice-water fountains.

As the water comes out into the open air, its carrying power is suddenly lessened, and the rock materials that have been banged about and rounded as they have been carried forward are deposited almost immediately at the front of the moraines. In this way ice-brought materials are carried beyond the limits of the region occupied by the glacier, and cover over the adjoining country, frequently forming a great plain such as the plain that slopes away from the southern edge of the Long Island moraine toward the sea. The sands and gravels that are frequently found in hollows high up in the hills of New England and New York were deposited by the streams of running water which flowed into temporary lakes, formed as the ice front slowly melted back. The fine soils that have been mentioned before, in the great wheat regions of Dakota and Manitoba, were formed as silt in the bottom of a lake that was in part held in by the great glacier, and are made largely from the materials brought by the glacier.

The Work of the Great Ice Sheet.—I have suggested that a glacier once covered northern North America as far south, in the eastern part of the United States at least, as the latitude of New York City. We know this because the conditions of soil, and the shapes and character of the hills north of this line, are similar in almost every way to the soil and earth forms made by the much-studied and famous glaciers of Greenland, Alaska, and Switzerland. In the glaciated region we find lakes by the thousand, some of them now changed into peat bogs, or filled with vegetation and rubbish, so that they have become dry and tillable land. We also find the soil in the valleys made up of all kinds and sizes of materials, often accumulated to a great depth, while the adjoining hillsides

have but a thin coating of soil, and the bare rocks are covered with scratches and smoothed and rounded very evidently by some moving body. The larger rivers follow valleys that were very evidently partly made before the ice occupied the country, as the valleys are covered with ice deposits through which the rivers are running as best they can. Oftentimes where the deposits were dumped irregularly over the former valley bottom, underlying masses of hard rock, little promontories that projected into the former valley, were covered. The river, cutting down into the glacial deposits, in time strips away the overlying soil, and then may find itself cutting across such a hard rock barrier, making a waterfall or a rapid. Such is the origin of thousands of waterfalls and rapids in New England and New York. (See Fig. 64.)

Furthermore, we often find boulders which can be traced back to the hill from which they were plucked, but which are now perhaps miles from their place of origin, and at rest upon rocks that are in no way like them. For instance, on Manhattan Island and on Staten Island, New York, very many large and small boulders may be found which are made of rock found nowhere east of the Hudson River. They must, therefore, have been brought across the Hudson by some force that could carry them uphill, and leave them very delicately poised, perhaps on the very top of a hill. On the island of Marthas Vineyard boulders have been found that could only have come from one particular hill about sixty miles away in a straight line, in the vicinity of Providence, Rhode Island. Such boulders give us a clue to the great distance that rock detritus may be carried by a glacier, without being worn out.

If we go south of the region of New York, we find a

very different condition of affairs. Lakes are almost entirely absent, the soils are not mixed-up accumulations of everything, but are like the rocks underneath, from which they have been made by slow decay. Ice scratches are absent; transported boulders, except those that have

FIG. 64.—PORTAGE FALLS ON THE GENESEE RIVER, NEW YORK. THE RIVER HAS CUT THROUGH THE OVERLYING GLACIAL DEPOSITS WHICH MAY BE SEEN IN THE BANKS.

tumbled down from some cliff under the pull of gravity or have been rolled down a valley by a river, are unknown; the hilltops may be covered with soil, and in some cases one may have to dig a great many feet before he can reach solid, unweathered rock.

In every way the evidence is strong that the erosive

processes of the atmosphere and the running water have been at work for a very long time, uninterrupted by any such great accident as the oncoming of the glacier. It is from the careful study of such facts as these that we have been able to determine the area formerly covered by the ice, and to reproduce in our imagination some of the conditions which existed when the glacier was here. Glacial work is the only great erosive force that we cannot see operating actively about us, and yet it is the force that has changed and shaped the surface of the earth in our immediate vicinity more than any other, and on the forms of land made by the ice we are very largely dependent for our means of living.

Summary.—The general result of the several kinds of work that we have been considering is the cutting of any land mass into valleys and hills, and the general lowering of that land toward the level of the sea, through the removal of the loosened detritus in the ways we have suggested. The changes thus brought about are made on the very surface of the earth, and take place, of course, very slowly. Could man live long enough in one spot, however, he would be able to see that century after century the amount of change would accumulate, so that after a very long time the land would be very different from its original form. In other words, the land features, in time, grow old, and finally they may be worn down close to the level of the sea, the rocks that have existed in the hills and mountains having been removed bit by bit to a new resting-place beneath the ocean.

Land forms thus have a history, and their appearance at any time depends upon their age and the experience they have had in life, just as we may tell, from the wrinkles in a man's face and from his general air, something

of his age and experience. As in man the wrinkles and changes are but surface features, and are determined in their character by the underlying skeleton of the face, so in the land forms the hills and valleys that are formed and developed during the processes of change are determined in their character by the kind of land form in which they have been cut and developed. In other words, if we look beneath the surface features made by the thin layer of soil, it will not be difficult to see that each land form has a certain skeleton, varying in character according to the way the mass of land was first accumulated as rock, and later revealed on the surface of the earth, to be attacked by the erosive forces.

THE GREAT LAND FORMS.

CHAPTER XII.

PLAINS AND PLATEAUS.

WE have already seen that most of the rocks of the continents have been formed beneath the sea in layers, and afterwards raised or tilted or crumpled until they have come above the sea level and become part of the continent. In other cases the rocks have been poured out in a liquid condition upon the surface of the earth through volcanic openings, and have there cooled or frozen into a permanent, solid form. In still other cases the liquid rocks have cooled and hardened far down in the earth, and are now exposed through the slow removal of the cover that formerly protected them. In general, such large and extensive forms added to the continents in the ways suggested may be grouped into *plains*, *plateaus*, *mountains*, and *volcanoes*. The greater land forms of the world belong in one of these four groups; but the general features that any particular area presents to us now depend on the amount of change or aging that that area has undergone since it first became a part of the continent.

Plains.—The first and most important of these great land forms are plains, of which a good example is the great *coastal plain* (see Fig. 65) which has recently risen

from beneath the Atlantic Ocean, and which now borders the American continent in a broad stretch extending from New York southward along the Atlantic coast and around the Gulf coast far into Mexico. Should we follow this plain by soundings beneath the level of the ocean, we would find it sloping equally gently for about a hundred miles off shore until we came to the edge, where the

FIG. 65.—A BIT OF THE COASTAL PLAIN IN MARYLAND, SHOWING GENERAL CHARACTER OF A YOUNG PLAIN.

depth would increase very rapidly. This unexposed part of the coastal plain is known as the *continental shelf*, on which the detritus of the continent is now accumulating and forming into layers, perhaps later to be added to the continent, thus widening the coastal plain.

This plain throughout its greater extent consists of a broad upland, sloping gently from the older land in the interior of the continent to the seashore. The rivers that run across the coastal plain have cut shallow, some-

what steep-sided valleys into the plain, not large enough, however, to be the seat of occupation. Riding across the plain, one would not be aware of the valleys until he came to the very edge. Such a stage of development may be illustrated very well in New Jersey and Maryland, and we may well speak of such a plain as being

FIG. 66.—A YOUNG VALLEY IN ALABAMA. NOTE THE STEEPNESS OF SLOPES AND NARROWNESS OF VALLEY BOTTOM.

youthful in character, for not much of the upland surface has yet been removed. On the upland the people live, devoting their attention mostly to agriculture, made possible through the richness of the soil of the weak rocks of the plain.

Had this plain been elevated much higher when it was added to the continent, the river valleys would have been cut much deeper, and the chances of tributaries to be

developed would have been much greater, so that the country would have been entirely cut up into hills and valleys, and by this time perhaps very little of the upland left. We might then say that the plain would be *middle aged*. As the hills gradually wear down in the later life of a plain, the topography would be more rolling, less uneven, and the country would be *old*. These several stages of age in plains, together with all the other stages of development, can be illustrated by watching the rapid

FIG. 67.—THE NIAGARA RIVER ABOVE NIAGARA FALLS, FLOWING ACROSS A FLAT PLAIN.

wearing away of a small plain made in a mud puddle during a rapid and heavy rain. If we look at the mud-puddle plain as the representative of a great continent plain, and watch the movements of the ants crawling over it, and see how they are hindered by the increasing roughnesses of the plain as it grows middle aged, and how they are aided by the smoothness of old age, we can get something of an idea of the way men may be hindered or aided in their life by the roughness or smoothness of the land on which they live.

A plain may be defined as a broad, gently sloping area bordered by higher lands on one or both sides. The Atlantic Coastal Plain, which has been mentioned, is bordered by higher land to the west in the Appalachians; the Great Central Plain of the United States and Canada, extending from the eastern Appalachian Highlands to the western Cordilleran Highlands, is a good illustration of a great plain bordered on both sides by higher lands. (See Fig. 67.)

Plateaus.—Certain parts of the country, particularly in the region drained by the Colorado and Columbia rivers of our great West, and in the so-called Alleghany Mountains of the East, are known as plateaus. In many ways their features are similar to those of plains, except that their altitude is relatively great, and that one ascends to or descends from them rapidly. In the case of the Alleghany Plateau we have a broad, nearly flat-topped stretch of land, in some cases more than twenty miles wide, that rises abruptly from the great valley of the Tennessee River on the east, and also from the lowland on the west. In the case of the Colorado, one ascends to the plateaus by climbing up the very steep slope on at least one side, and perhaps then descends very gradually on the other. As a plain is found to be bordered on at least one side by rapidly rising higher land, so the plateau is found to be bordered on at least one side by a steep descent. In some cases this descent is equally abrupt on both sides.

The amount of upland in the case of any plateau depends, as in a plain, on the number and size of the river valleys that have been cut into it since it was elevated. In the southern portion of the Alleghany Mountains, in the so-called Cumberland Plateau, the river valleys are

few and small; one can ride miles on horseback straight across country without crossing any ravines of any size, and paying no attention to roads. In the northern part of the same region, in West Virginia, where the plateau is known as the Alleghany Plateau, the river valleys are

FIG. 68.—THE VALLEY OF NEW RIVER, WEST VIRGINIA, SHOWING STEEP SLOPES OF A YOUTHFUL VALLEY CUT INTO A PLATEAU.

much more numerous, and are mostly steep and narrow. (See Fig. 68.) Here the amount of upland has been greatly reduced, and the country is one of ups and downs. Cross-country travelling is therefore difficult, and the people must live on the slopes or in the bottoms of the river valleys rather than on top of the plateau,

as in the case of the southern Cumberland. In both instances heavy forests cover the hilltops and valley sides. In the Cumberland region there are few settlers, owing to the fact that the region is somewhat inaccessible to any large towns; the people are therefore very much dependent upon their own resources, produce most of the necessaries of life, and devote their attention largely to grazing, in spite of the fact that beneath the surface of the earth there is a very great quantity of coal, which makes this area one of great mineral richness. The coal, however, cannot be readily worked, because it is covered by a heavy and strong layer of rock that makes mining difficult and expensive. In the Alleghany region, however, where the river valleys are numerous, the layers of coal are exposed all along the sides of the valleys, so that it is an easy task to dig the coal from the earth. As a result, the country is thickly occupied with mines, and mining is the most important industry. Such a region is a good illustration of a middle-aged region, in which the river forces have accomplished a great many changes since the land was first built into a plateau, but where there is still a great quantity of work to be done before the plateau is worn down level, or nearly level, presenting the features of an old region.

CHAPTER XIII.

MOUNTAINS.

In some ways the most interesting of the greater forms of the land are mountains. Though a mountain is usually considered as a peak of land rising to a high level above the sea, we have already seen that single mountains are rare, and that individual peaks are usually but points in a mountain range. Great mountain ranges, like the Appalachians or the Cordilleras of this country, the Alps in Europe, the Himalayas in Asia, are extensive highlands, many times as long as they are wide, extending across the country as a great barrier to ready travel, and rising to varying heights in the different regions. Indeed, mountains are sometimes considered the only form of highland; but many of the plateaus of the world, as, for instance, in our own Western region, are in reality highlands, rising as they do perhaps a mile and a half above the level of the sea. The form and shape of such areas prove them not to be mountains, in spite of their altitude.

Mountains stand at a height because they are composed of strong rocks which the erosive forces of air, water, and ice have not yet been able to wear down. We thus find that mountain masses, as a rule, are the sources of rivers, and that the slope of the valleys cut into the mountains is steep. This steepness of slope, accompanied, perhaps, by the narrowness of the valleys, makes the building of footpaths, railroads, or roads across

mountains a difficult and an expensive matter, so that most mountain barriers are crossed by roads or railroads at but few places, and then at the pass between the higher peaks. (See Fig. 69.) The steep slopes of the mountains in the lower portions are usually occupied by forests; as we ascend higher and higher the trees grow smaller, until on the high mountains in our own tem-

FIG. 69.—A MOUNTAIN PASS IN IRELAND, SHOWING BORDERING PEAKS OF RANGE.

perate region we may rise above the line where trees can grow, into the region occupied only by lichens and mosses, or perhaps to the region of perpetual snow. In the frigid belts, mountains are covered by snow to the very sea level; but in the tropical regions, as, for instance, in the Himalayas, snow is not found on the mountains except above a height of about 20,000 feet.

The line above which snow remains the year round is

known as the *snow line*, and but a little below the snow line is found the *tree line*, the region between being occupied in the summer by the lowly forms of plants noted above. (See Fig. 70.) The strong rocks of which mountains are made are very frequently full of rich and valuable minerals and ores, so that the one great industry

FIG. 70.—A MOUNTAIN IN BRITISH COLUMBIA, SHOWING SNOW LINE AND TREE LINE.

associated with mountains is that of mining. Except where people have been attracted to mountains for their mines or timber, or because of their healthfulness or beautiful scenery, we find mountainous regions but little occupied. (See Fig. 71.) We think of them, therefore, as regions of wildness, given over to forests and wild animals, such as bears, wildcats, Rocky Mountain goats, etc.

Mountain Building.—The rocks that make mountains have in some way been heaved or crumpled into great folds or ridges, the individual layers not lying in a generally flat position, as in plains or plateaus, but crumpled and contorted, and perhaps almost on edge. This crump-

FIG. 71.—A PROMINENT MOUNTAIN PEAK IN CONNECTICUT, SHOWING TILLED FIELDS AT BASE, WOODED STEEPER SLOPES, AND SUMMIT WITH A LOOKOUT TOWER.

ling or folding of the rocks of a mountain range, so that they do not spread over as wide an area as formerly, is what determines whether a region is mountainous or not. We may thus have mountains of low altitude, as we can have plains or plateaus of high altitude. The idea of mountain building involves not only elevation, but tilting or folding of the rocks as well. (See Fig. 72.) Any

cause, therefore, that will tip or crumple the rocks of the earth, is a mountain-building force. The rocks exposed on Morningside or Washington Heights in New York City, or in the complicated folds to be seen in many places in the Borough of the Bronx, have been mountain

FIG. 72.—A SMALL MOUNTAIN FOLD AT CATSKILL, NEW YORK.

built, and present to us beautiful illustrations of small-scale mountains.

Causes of Mountains.—We frequently see the statement that the rocks of certain parts of the earth's surface have been crumpled into great folds in order that the surface rocks may fit the interior mass of the earth, which has been growing smaller as it has cooled from

a previous very hot condition, just as the thick skin of a baked apple shrivels and crinkles as the apple cools. This to a certain extent is true; but it is not the only cause of mountain building.

Indeed, the causes of mountains are probably so numerous, and are so complicated, that no one knows them all. We must therefore acknowledge the difficulty of explaining mountains, and accept them as the results of forces beyond our present understanding. Perhaps one more suggestion, however, may be given here. Sometimes it happens that when a great quantity of gravel and rock is built out in a long railroad bed on the muds of a flat marsh, the marsh will rise in folds on the two sides of the roadbed, as recently happened in Pelham, New York. The mountain building in such a case is due to the weighting down of the marsh materials in one spot, which are thus squeezed sideways until finally they buckle into folds. In a similar way, it is supposed that the continued removal of materials from the surface of the land to the shore parts of the ocean causes a down-weighting on the sea floor that makes the adjacent rocks of the land crumple into mountains, whose general direction will be nearly parallel to the old continent.

Kinds of Mountains.—Mountains are most frequently folded into long, parallel ridges, as a series of sheets of tissue paper would be crumpled into folds if one edge were held firm and the other edge pushed. Such linear or *folded* mountains are well illustrated in the Appalachians, where the ridges are repeated one after another, each running in the same general direction, with valleys between, which have recently been formed in the weak rocks. Sometimes the mountain masses are raised into a dome from the pushing from beneath, very much as

the bottom of a tin pan will rise into a dome if pushed upward. Then the layers of rocks will slope away in all directions from the centre. Such *domed* mountains are particularly well illustrated in the Black Hills of Dakota and in certain other regions of the West. Occasionally a great series of stratified or layered rocks have been broken and tipped on edge, so that the edges of the blocks stand up in steep slopes, with the original surface sloping away in the opposite direction. We can see such *block* mountain topography illustrated in a simple way when the ice in a river or lake becomes broken, the blocks of ice tipping in several directions, and perhaps freezing together again in their new positions, making a very irregular or hummocky surface, difficult to cross.

It is easy to see that one series of resistant layers, tilted and broken in such a way, may make many mountain ranges, varying with the number of blocks into which the original mass is broken. Certain of the mountains of Washington and Oregon, and certain of the elevated peaks of the Connecticut Valley, have been formed in this way. Whatever the class of mountains, the result is the same:—an elevation of rocks, with a tilting or crumpling of the layers, that raises a large amount of material to a sufficient height to allow river valleys to be cut into it.

Aging of Mountains.—Mountains, as well as plains and plateaus, grow more irregular as the rivers develop, and a young mountain range would be one in which the original form was but very little changed through the subsequent cutting of river valleys. This type is perhaps best shown in the block mountains of Oregon. With increased aging the mountains become more cut

up, more irregular, more divided into peaks, ridges, ravines, and valleys, and thus more beautiful. In such dissected mountains, people may live in the different valleys, as in the case in the Swiss Alps, each valley community almost as separate and distant from its neighbors as though divided by miles of water instead of perhaps by a single ridge. As the mountains grow still older, they will of course be worn down lower and lower, until they may appear as a lowland, more or less like a plain. The fact that the rocks of such a region are twisted and folded and deeply weathered on the exposed surface testifies that the region was once mountainous, though not now showing many signs of mountain topography. Such an old mountain lowland is well shown in this country in the so-called Piedmont (foot of the mountains) region of Virginia, lying between the higher ranges of the Blue Ridge, as that portion of the Appalachians is called, and the low-lying eastern Coastal Plain. In this Piedmont region the old mountains have not been worn absolutely flat, but nearly so. Here and there peaks rise to a moderate height, showing where the old mountain rocks were strongest and most resistant, or where for some other reason the erosive processes have not been able to do all their work.

Such lowlands, formed by the erosion of old land masses, are sometimes called *peneplains*, because they are almost plains. (See Fig. 73.) Since they have been made, however, they may have been raised to a greater height, so that the even line which marks the level of the plain may be visible only to one who climbs out of the recent valleys to the tops of the ridges, and thereby stands upon the elevated lowland, now being eroded and dissected again. In southern New Hampshire is a fine illustration

of such a peneplain, above which certain peaks rise majestically, of which Mount Monadnock is a noble example. Hence those points which have never been worn to the lowland level are sometimes called *monadnocks.* We need not, however, go to New Hampshire to find such a peneplain, made in old mountain rocks, for New Jersey shows the same features most beautifully. One standing

FIG. 73.—A BIT OF A PENEPLAIN IN CONNECTICUT, SHOWING STEEP-SIDED YOUNG VALLEY CUT BELOW LEVEL OF UPLAND.

on the edge of the Orange or Watchung Mountains in Montclair or Orange, New Jersey, sees all the ridges about him at approximately the same level, marking the old peneplain. Below him are the valleys cut in recent times, and far away to the northwest may be seen occasional small monadnocks rising a few hundred feet above the even sky-line of the peneplain.

Thus as mountains grow older and lower, their majesty and variety of topography disappear, and plants, animals,

and men no longer find in the mountains, regions that cannot be occupied because they are too high and too hard to reach. The region can be used, perhaps, for agriculture and other occupations. If the original mountains contained minerals of value, man has lost so much possible wealth through the wearing away of the rocks and the removal of the minerals bit by bit to the ocean. Men living in the river valleys near mountains that are now wearing away and sending down to the rivers bits of gold with the gravel and sand, often wash the gravels and catch and save the specks of gold; this form of mining is known as placer mining.

CHAPTER XIV.

VOLCANOES.

VOLCANOES make up the fourth and last of the several great groups of land forms that we have to consider. Volcanoes are not as important or as numerous in the world as are the plains, plateaus, and mountains. They are, however, extremely interesting, and are full of wonderment to most people because of the awe associated with them. A volcano is essentially an opening in the earth from which the pent-up energy of the interior escapes as steam, very much as steam escapes from an engine when the pressure gets too high. As the heat and water making the steam come from a great depth in the earth, the crack or opening by means of which they reach the surface must extend many thousands of feet down into the earth. The escaping steam frequently, and indeed usually, melts the rocks through which it comes, making them sufficiently liquid to boil to the surface almost as easily as the water. Thus in most volcanic eruptions we have, besides the ever-present steam, the pouring forth of an enormous quantity of rock, in a liquid form, known as *lava*.

If the energy of a volcano is very severe, the steam penetrating through the liquid lava blows it into bubbles, very much as a small boy blows soapy water into bubbles ; the lava may then come forth upon the surface of the earth, and afterwards cool into a mass of rock full of

rounded holes, just as cheese or bread is sometimes full of gas or steam holes. When the holes are small and very numerous, the rock is called *pumice-stone*. If the energy is sufficient to have the bubbles burst, then the rock materials that formed the surface of the bubbles are blown into very fine dust-like particles, known as "ashes," or "cinders." This again is sometimes illustrated in the blowing of soap bubbles when the bubble bursts, and the thin film of water that formed the surface of the bubble spatters into the blower's face as several small drops of water. As a matter of fact, there is no burning of the rocks in a volcanic eruption, and hence there can be no real ashes. The material is spoken of as "ashes" because it is so fine and ash-like in its appearance.

Any eruption beginning in a severe way may blow the ashes into the air to a tremendous height, so that they are wafted by the winds far and wide, perhaps forming a cloud that makes the day dark, and which may cover everything with a thick layer of dust as they fall. The famous eruption of Vesuvius in the year 79, when the ashes and lava buried two cities, Herculaneum and Pompeii, was of this character. A very great series of violent eruptions occurred during the summer of 1902, in the islands of Martinique and St. Vincent, in the Lesser Antilles. These eruptions caused an enormous loss of life and property, and were the most destructive eruptions ever known. Great clouds of ashes and steam hung over the islands, and the dust fell upon vessels several hundred miles away. (See Fig. 74.) No liquid rock, or lava, was poured forth, however, in the several very violent eruptions which occurred between May 8 and August 30, 1902.

During the latter part of an eruption, when the energy

has decreased, the lava may pour forth, and flow down over the neighboring country. After the lava has ceased to appear at the surface, the steam may continue to escape from the volcanic opening under the earth for a long time, and the lava may be heard or felt boiling or rumbling in the depths below. Indeed, some volcanoes

By courtesy of American Museum of Natural History.

FIG. 74.—MONT PELÉE IN ERUPTION.

are continually rumbling and steaming, but burst forth in an eruption only at very long intervals.

Shape of Volcanoes.—The solid material poured out in either of the forms mentioned may accumulate near the volcanic opening, and gradually build up a great heap of materials, until we have a great conical elevation of land, known as a volcano. Volcanoes are sometimes

spoken of as mountains, because of their height; but they are not mountains, as there is not necessarily any upfolding of the rock layers such as we find in mountains. The conical shape is common to most of the well-known volcanoes of the world, of which the two best examples are perhaps the famous Vesuvius, in Italy, and the still more beautiful and symmetrical Fuji-yama, in Japan. A volcanic cone has at its top a cup-like depression known as

FIG. 75.—SMALL AND VERY SYMMETRICAL VOLCANIC CONE IN OREGON.

the *crater*, in the centre of which is the opening known as the *throat*. The throat, the crater, and the cone are common features of all volcanoes, though the features of each may differ in different volcanoes. (See Fig. 75.) Each time that there is an eruption of lava, the moving flood of rock flows down depressions in the sides of the volcano like water, seeking the lowest level. If the eruptions are a sufficiently long time apart to allow the cutting of river valleys into the volcano, the next eruption will

probably more or less fill the depressions, thereby renewing the symmetrical conical shape of the volcano. By studying the relations of the different flows of rock to one another, it is possible sometimes to work out the order of their appearance, and to get something of the story of the upbuilding of the cone as a whole.

Kinds of Volcanoes.—There are two classes of volcanoes; one that is high and narrow, and the other low and broad. Vesuvius is a good illustration of the first class of volcanoes, for it has a steep cone and a small cup-like crater at the top. By far the larger number of the great volcanoes of the world belong to this class. In some cases, however, volcanic peaks occur as caps on the top of mountain ranges, so that the full height and size of the peaks are not due entirely to volcanic action. Such, for instance, are some of the famous volcanoes of South America, like Cotopaxi and Chimborazo.

The second great group of volcanoes has a low, flat cone, with a broad, saucer-like crater in which the lava may stand sometimes as a great lake, for years, slowly rising and falling, until it finally overflows, allowing the lava to escape to lower regions. Such are most of the volcanoes of the Hawaiian Islands. Owing to the size and shape of the crater, there is not so great an opportunity for the energy to be held in, in this group of volcanoes, as in the first class, and hence the eruptions are likely to be more quiet and less renowned.

Sometimes we have evidences that great volcanic outbursts have occurred in different parts of the world, not apparently from any single cone or crater, but perhaps from a group of craters, or possibly from a series of great cracks under the earth, from which the lava has poured forth in tremendous volumes. In our own great West,

as is well illustrated in Oregon and Idaho, we have thousands of square miles of country covered by an unknown depth of lava, which apparently poured forth in some such way. There are also extensive lava fields in Arizona. (See Fig. 76.) The lava, like water, filled all the depressions in the land to a level, and then froze permanently into solid rock, so that we now have a great lava plain made up entirely of such frozen lava, and resembling,

FIG. 76.—A VOLCANIC CINDER CONE AND LAVA FIELD IN NORTHERN ARIZONA.

both in manner of origin and in shape, the winter ice plains made by the temporary freezing of water in lakes.

Aging of Volcanoes.—Many of the volcanoes of the world are no longer active, but are in various stages of aging, depending upon the amount of weathering that has taken place since they became inactive. The inactive volcanoes that are the most youthful in their topography are those where activity has just ceased, and where the lava filling the throat of the volcano has become frozen as a solid plug, bearing the same relation to the volcano

that a cork does to a bottle. In such cases the crater no longer has an opening in the bottom, but, like a wash-basin, is capable of holding water. As a result, the rainfall accumulates in the crater depression, forming a lake, which may rise until the water can flow out at the lowest point of the edge. In the centre of France there are many such instances of inactive volcanoes, each with its crater lake in its summit. Such volcanoes must, of

FIG. 77.—PANORAMA OF CRATER LAKE, OREGON, INCLUDING WIZARD ISLAND.

course, be very young, because if a long time had elapsed since they last were active, the rim of the crater would have been more or less worn away, so that the water could escape.

In Oregon we have a famous Crater Lake, not quite similar to those in France, but still a lake, lying in the summit of an ancient volcano. (See Fig. 77.) In this case, however, the top of the original volcano has disappeared, and we now have a great depression, with cliff-like walls many hundred feet in height. Since that time a small new cone has grown up within the great depression,

and thus we have one cone within another. This small cone forms an island, known as Wizard Island. In the course of time, however, as the volcano grows older, the cliffs will be worn down and the water of the lake will thereby be drained away.

We have a similar condition in the case of Vesuvius, where the present cone lies in the centre of an old de-

FIG. 78.—ONE EFFECT OF AN EARTHQUAKE IN LOS ANGELES, CALIFORNIA, IN 1899.

pression which is bordered on all sides by cliffs which are the remains of the top of the old cone.

As volcanoes wear away, those portions which are made of the most resistant or strongest rocks will resist weathering the longest; hence a volcano will be cut into peaks, ridges, and ravines, very similar in form to those of domed mountains, the ravines heading toward the centre of the volcano, and radiating out like the spokes of a

wheel, as is illustrated on the sides of the ancient and well-worn volcano of Mount Shasta, in California. When volcanoes have been worn down nearly flat, the last remnants, standing as elevations above the eroded land, will, of course, be where the strongest rocks occurred. Usually the solid lava that filled the throat of the volcano resists

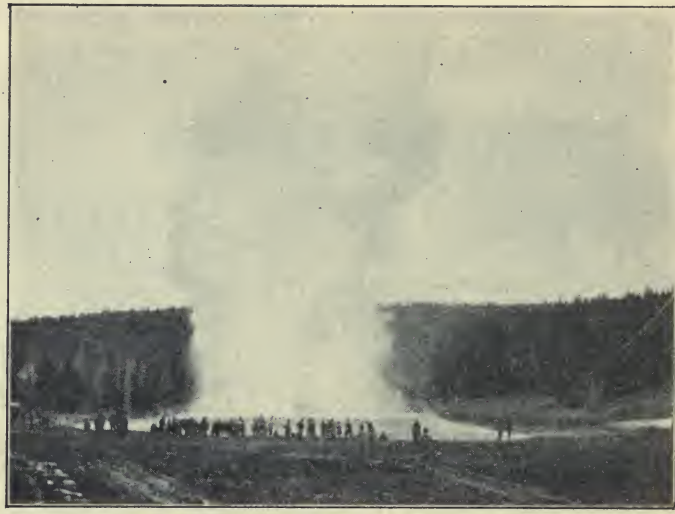

FIG. 79.—AN ERUPTION OF THE GIANT, THE LARGEST GEYSER IN YELLOWSTONE PARK.

weathering the longest, so that the last sign of a volcano in a region, at least as shown in the topography, is the presence of a *neck* as a conspicuous landmark in the plain. Such necks are the worn-out stumps of ancient volcanoes, and are sure signs of the former presence of a great cone that has been worn away. In certain parts of Arizona and New Mexico there are beautiful illustrations of such old volcanoes, rising conspicuously above

the old plain down to which the rest of the region has been worn.

Earthquakes.—Associated with any great volcanic eruption there is always a series of earth tremblings, known as earthquakes. Such quakings are due to a blow given in some way to the rocks in the interior of the earth, so that they vibrate as a bell vibrates when struck

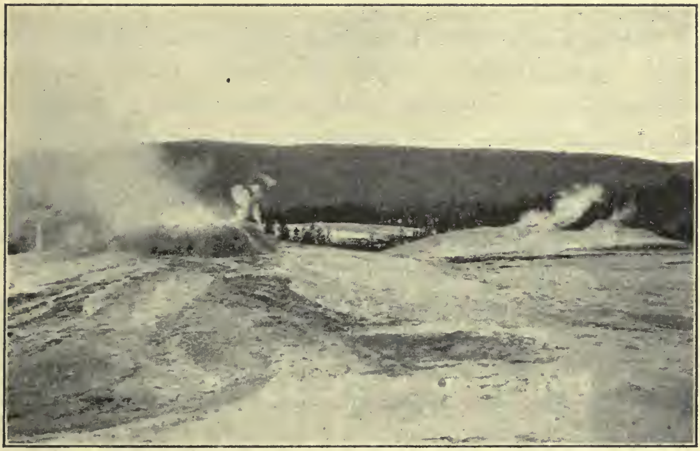

FIG. 80—A GEYSER CONE AND FIELD IN YELLOWSTONE PARK.

by the hammer. Sometimes the earthquakes are sufficiently strong to shake down houses, and to cause other injuries to man's property. (See Fig. 78.) All earthquakes are due either to volcanic explosions or to movements in the rocks due to mountain building going on beneath the surface of the earth. The oncoming of an eruption in a volcano may often be foretold by an increase in the frequency, and perhaps in the strength, of the earthquakes in the neighboring region. Indeed, volcanic

countries like Iceland and Japan are famous earthquake regions. Certain parts of Japan are shaken every year by several hundred earthquakes of sufficient strength to be felt, if not by men and animals, at least by delicate instruments that have been made to measure and record such earth movements. The greater part of the world is, however, free from frequent or severe earthquake shocks, and most of the people in the United States have never experienced any severe earthquakes.

Geysers and Hot Springs.—Volcanoes are not the only forms, however, which are made from materials brought from within the earth by hot water. Sometimes the heated waters that rise to the surface as hot springs bring with them in solution a certain quantity of mineral matter, which, crystallizing as the water cools, accumulates as deposits around the spring, just as sugar solidifies from a syrup when it is cooled. A similar accumulation may take place, often to a considerable depth, around those intermittent or spouting hot springs that are known as *geysers* (see Fig. 79), of which the best and most numerous examples are found in the Yellowstone National Park. There the geyser and hot-spring deposits cover a large area, and are in certain places of great depth. (See Fig. 80.) The geyser and hot-spring cones have many features similar to those of volcanoes, particularly in shape, although, of course, they are smaller in size. Hot springs, geysers, and volcanoes are but different illustrations of the activity of heat from within the earth, the heat of hot springs and geysers, however, being less intense than that of volcanoes, and their eruptions less striking and awful.

CHAPTER XV.

MOVEMENTS OF THE LAND.

WE have already seen some of the effects of the slow upbuilding of mountain ranges, and the slow rising of the coastal parts of the land, whereby the bottom of the ocean may become revealed as a coastal plain bordering the water. Movements of the continent, or of parts of the continent, are very slow, but continuous, as is indicated by the frequent earthquakes in regions which are not volcanic, and where, therefore, the tremblings must be due to mountain building. After a long period of time, however, the effects of these movements may be seen in some of the new conditions which they bring about.

It is very rarely that any man can see in the course of his life any movement sufficiently great to make any change in the features about him; but yet he can be sure that such movements are taking place by studying some of the features about him that evidently could not have been made with the land in its present position in reference to the ocean. For instance, in Norway there is a great cave on the coast facing the ocean, but now several hundred feet above sea level. In that cave are the rounded, water-worn pebbles that show by their shape how they were formed: they testify to former water work in the cave, and, indeed, they were the tools that the water used in cutting the cave. As the cave could

not have been cut in its present position, the story it tells is clearly to the effect that the region has risen in very recent times. There are many other similar instances in various parts of the world that prove without any doubt the recent movements of the land.

Of course the movement may be upward, so that the land is raised above the ocean, causing perhaps a large area of ocean floor to be added to the continent; or the movement may be downward, so that the water of the sea advances over and covers parts of the land.

Coast Lines.—The first sign of such a change in the relative position of the land and ocean is the new coast line, the new meeting place of land and water. If the movement has been upward, the former coast line will thus be raised and carried away from the ocean, so that it appears on the sides of the hills, but with every feature retained. Indeed, the features may be so carefully preserved, and so striking, that one standing on the old sea beaches or capes, with his back to the distant ocean, might easily imagine himself on a present sea beach at low tide.

If the movement is downward, the water naturally advances upon the land, fitting into all the irregularities of the land, and filling up the hollows to a common level. The more irregular the land surface when the movement takes place, the more irregular the coast line that will result. Such an irregular coast line, formed in this way, is commonly spoken of as that of a *drowned* region, inasmuch as part of the old land surface has been carried below the water level, or, as we may rightly say, drowned. (See Fig. 81.) If the land that was drowned was made of rocks of varying hardness, and much cut up into hills and valleys, the shore line will be much more irregular

than if the region had been one of relatively uniform strength. The water, rising up into the river valleys,

FIG. 81.—MAP OF A DROWNED VALLEY IN MARYLAND. NOTE FORMATION OF PENINSULAS, IRREGULAR CHARACTER OF COAST LINE, AND POSITION OF ROADS AND HOUSES.

would wash the shores of the old hills, and perhaps cover some of them. The higher peaks would remain perhaps

above water, as islands or peninsulas, the islands in line with the higher peninsulas, thus indicating the direction of the drowned ridge. (See Fig. 82.)

It is largely through drowning that peninsulas are made, and many of the capes of the world are on the

FIG. 82.—A STRONG ROCK PENINSULA AT MARBLEHEAD, MASSACHUSETTS, FORMED BY DROWNING.

seaward end of strong rock ridges, most of which have been drowned. A slight downward movement of the land in reference to the water might cause the point of a peninsula to become an island, or if the movement were in the opposite direction, the island might again be joined to the mainland, and be added to the promontory as a peninsula, thus lengthening the point.

Drowned Valleys.—The more complete the drowning, the fewer ridges whose tops would project above the water, and hence the more regular the coast line. In the vicinity of New York the drowning has allowed the water of the ocean to penetrate for miles inland along the river valleys, as in the cases of the Hudson and Delaware rivers and in Chesapeake Bay. This makes it possible for ocean vessels to go directly from foreign ports to large cities which are actually, as in the case of Philadelphia or Baltimore, a long distance from the open sea.

How are we to know, therefore, that a given valley has been drowned? In the case of certain parts of Chesapeake Bay it is very easy to reproduce in one's imagination the courses of the old rivers and their tributaries that ran along the deepest parts of the present bays or estuaries. (See Fig. 81.) We can see from the map that all the big bays point toward each other as the large rivers point toward a main stream; that all the small bays point toward the larger bays, and that, were the water to be drained off, the rivers that now mouth at the bays would continue down stream until they formed a river system again.

It is another matter, however, to tell that such a river as the Hudson has been drowned, and yet it is not difficult. In the first place, tides nearly to the source of the river suggest deep and quiet water, and, of course, a level very close to that of the ocean. Then, again, the amount of water in the Hudson at any one time is very large, and the area from which the Hudson receives drainage is altogether too small to supply it all. Therefore there must be some other water than rain water in the river, and as the water is salt, it must be ocean water. This of course means a depression that has allowed the ocean water to

come in, for rivers cannot cut down the channel of their whole course below the level of the sea. The drowned Hudson River, and the adjacent East and Harlem rivers, have given splendid opportunity for commerce, and the hilltops that were never completely drowned, but which rise in Manhattan Island, Long Island, and Staten Island, are but the undrowned hilltops of a former extensive land surface that offer a chance for the position of large cities. Were the land in this region to rise again, so that the water of the ocean were drained off to the extent it once was, Manhattan Island would be but a hilltop, seventy-five miles inland, in every way similar to hilltops that appear to-day in western Massachusetts and Connecticut.

We have already suggested, in the early part of the book, some of the effects of such drowned shore lines in making a large area of land available for occupation, and for the development of agriculture and commerce. Straight and regular shore lines, formed usually by the elevation of the land, so that the waters of the ocean wash against the even slope of the newly elevated sea bottom, making a coastal plain, have but few breaks through into the interior, offer few chances for harbors, and give but few people ready access to the water; whereas on an irregular, or bayed shore, many people can have their own bit of shore where they can land vessels, the bays giving a splendid opportunity for protected harbors.

CLIMATE.

CHAPTER XVI.

WHAT IS WEATHER AND CLIMATE?

PERHAPS the first thought that comes into one's mind when we ask whether a certain region is habitable or not, is the question of climate. The great climatic divisions of the world mark out the regions in which men, animals, and plants can live, and in those different regions we find that the topography has much to do in determining how large a proportion, and what parts, may be occupied by life to the best advantage. In considering the climate, therefore, we must think of many things that belong to the world as a whole; we must study that world so that we can divide it, according to its climate, into the habitable and the uninhabitable regions.

It would be well at the beginning to find out exactly what we mean by climate, for sometimes we speak of a dry or a wet climate, a cold or a warm climate, an unhealthy climate, etc. Does this mean one and the same thing, or is climate really a very complicated matter, made up of a number of different features?

In speaking of the climate of a region, we of course think of the conditions of the air, just as the weather any day includes all those atmospheric conditions that affect us. Indeed, the climate is but the average of these weather

conditions by seasons, and is determined, of course, by studying the weather for a long period of time, and finding out what features of the weather are most common and may be expected most frequently in any particular region. As climate, therefore, is but average weather, we had best first see what it really is we familiarly call the weather.

Weather and Climate.—When one person remarks to another that this is fine weather, he probably has in mind, first, the fact that the day is clear, rather than cloudy or stormy, so that the kind of day is perhaps the first point to be considered as a part of weather; in a similar way, in a study of climate the average character of days in the different seasons, whether they be clear, cloudy, or rainy, determines the general climate; for regions where there are many clouds and much rain must be moist, and those where it is generally fair must be more or less dry.

Next to the kind of day is the question of temperature; that is, whether the day be cold, cool, warm, or hot. We shall find, however, that sometimes the days in which the temperature is the highest or lowest do not make us feel the most uncomfortable, and in the summer, at least, the most disagreeable days are not those which are in reality the warmest, although we may think from our own feelings that they are very hot. We expect cold days in the winter season and hot days in the summer season, and in deciding upon the climate of any region we have to take into account the general temperature conditions at the different seasons. In the same way, in deciding upon the climate of any part of the world we have to think whether the temperature during the year is uniformly cold, or hot, or variable. Those regions which have extremely low temperatures in the winter,

and no long-continued warm spells during the year, we speak of as arctic in character, and as having an arctic climate. Those that are extremely warm the year round, with but little change of temperature from month to month, we speak of as being tropical in their nature.

The third matter that has to be considered in determining the climate, or weather, of a region is something that we do not ordinarily notice from our own feelings, and that is the weight or the pressure of the air. And yet this is a very important matter, because it is a difference in weight of the air in neighboring places that gives us our winds, the wind being air in motion over the earth, from where there is a great deal of air to a region where there is less air, or from where the air is heavy to where it is light. It is very easy to show, as, for instance, by blowing against a piece of paper, that air has weight and can give a push; but it is hard to illustrate changes in that weight without the use of instruments. We can, however, as we shall see under the study of the winds, find out where the air is light and where it is heavy; and if we find that in any parts of the world the winds are in general from particular directions, we know at once that the air to leeward is always lighter for some reason than the air to windward.

Next to the kind of day and the temperature, in determining whether the weather is agreeable or disagreeable, is probably the question of the wind. A windy day, particularly when it is cold, or when it is hot and dusty, is one of the most disagreeable of days, no matter what the other general conditions. A country in which the winds are prevailingly strong or boisterous has a disagreeable climate, whether it be cold or warm. We should probably find it equally disagreeable to live in

a region in which the winds were very light and infrequent, and where we were not cooled by the blowing of the air against us.

In thinking of the wind, we need to note its direction; that is, the point of the compass from which it is blowing, and the velocity with which it is moving. A wind that is moving over the ground at the rate of thirty miles an hour, as fast as an average railroad train, is a strong wind, and generally an unpleasant one. Wind that is moving at the rate of sixty or seventy miles an hour, as very infrequently happens in the Eastern United States, is a gale, destructive in its violence, and very hard to withstand if one must face it.

The next point that has to be considered in summing up the weather is the question of the amount of moisture in the air. It is very evident that when it rains or snows, or when there is a fall of sleet or hail, the air is full of moisture, some of which comes to the earth. When the air is full of moisture which does not fall, the weather may be as disagreeable as on stormy days. On damp, cold days the winds that strike us cut like a knife, chilling us with the moisture which they bring. If the day be very warm and moist, as it is frequently during the so-called dog days of summer, we feel sticky and lazy, and very uncomfortable. Again, a very dry, hot day may be equally disagreeable, because the moisture that is lacking in the air must be supplied in part from ourselves through evaporation. As we have certain days in the year that are very moist, and some that are very dry, so in certain parts of the world the average climate is wet or dry. Those regions that are excessively dry are deserts, and those that are excessively moist, other conditions being favorable, may be covered with luxuriant

vegetation, or filled with swamps, which are mostly uninhabitable, owing in part to the moisture, and in part to the fact that severe fevers are prevalent in such regions.

When there is a sufficient amount of moisture in the air to fall as rain or snow, it is necessary to catch the falling moisture and to measure it in order to get a clear knowledge of the amount of rainfall during a year. If the fall be in the form of snow, it is measured in its liquid form as water. The number of inches that fall over a given surface in a year gives us the rainfall of the region, a very important matter in determining the success of agriculture.

In speaking, then, of the weather we mean: first, that it is clear, cloudy, or stormy; second, that it is warm or cold; third, that the air is light or heavy; fourth, that the air is wet or dry, and, if it rains or snows, that the rainfall is heavy or light. It is the average of these several things that goes to make up climate, and as these factors may occur in almost any combination, it is possible to have almost any kind of climate in the different parts of the world.

We shall find, however, that the other features vary more or less with the temperature, and that a knowledge of the distribution of temperature over the world will give us a suggestion as to the other features of the climate.

CHAPTER XVII.

TEMPERATURE.

Measurement of Temperature.—When we speak of temperature, we mean the temperature of the air close to the surface of the earth, and we measure this temperature by means of a thermometer. A thermometer usually consists of a glass tube with a bulb at the bottom containing a certain amount of mercury, which is a liquid metal that readily changes its volume as it grows warm or cold. The tube of mercury is placed in freezing water, and a mark is made on the glass at the surface of the mercury after it comes to rest. This mark in the ordinary thermometers in every-day use is called 32°, or the freezing point. In a similar way the position of the mercury in the tube is found when the tube is in boiling water, this point being labelled 212°, or boiling point. The space between is divided into 180 equal parts, or degrees, and in a similar way the tube below the freezing point is divided into equal degrees. Thermometers divided in this way are known as Fahrenheit thermometers; and when we speak of a temperature of 10°, or 56°, or 100°, we mean a temperature sufficient to raise the mercury in such a Fahrenheit thermometer to the point indicated. The zero line is 32° below freezing, and below that point we measure the degrees from the zero limit, so that a temperature of 6° below zero, which is a very unusual temperature for New York City, means in reality 38° below the freezing point.

In some thermometers the freezing point is marked zero, and the boiling point 100°. In such instruments the degrees are consequently larger than in a Fahrenheit thermometer, there being but one hundred instead of one hundred and eighty degrees in the same space. We will refer continually to Fahrenheit temperatures, which in our ordinary experience range from something over 100° in the shade to a temperature of a little below zero. A permanent temperature of much over 100° could not be endured by men.

Source of Earth Heat.—The heat that comes to the lower portion of the atmosphere, the portion in which we live, comes almost entirely from the sun. The temperature of the air depends primarily upon two things, the amount of heat received and the amount that is retained by the atmosphere. The amount received depends almost entirely upon the angle at which the rays of heat strike the earth. We know, for instance, that in the morning and evening, when the sun lies low in the horizon, our shadow is several times our own length. We can see that the amount of light and heat which strikes us, and which is prevented from passing on, would, were we not there, be spread over an area approximately as large as our shadow, which is many times the area that we expose to the light and heat. As the whole of our shadow could not receive any more light or heat than we, it is very evident that any part of the shadow must receive a very small proportion of the light and heat that would come to it at noon time in midsummer, when the sun is high in the heavens and our shadow but little larger than ourselves. It is very easily seen, therefore, that, the more directly the rays of light and heat strike an object, the more that object will be heated or lighted,

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for the more heat or light will be spread over a given area.

As the rays of energy strike us obliquely in the morning and evening, and more nearly vertically at noon, giving us a weak amount or a large amount of heat to a given surface, so there are parts of the world where the rays of light and heat come very directly throughout a larger part of the year, and other portions where the rays are more slanting. There are still other regions where, at certain seasons, no rays come at all, because that portion of the earth is turned away from the sun. This is the case in the north polar regions in January (our winter) and the south polar regions in July (the southern winter).

The effect of the more direct and the more slanting rays of the sun is clearly seen by comparing a southern and a northern hillside in winter. The northern slope, receiving the more slanting rays, is the colder. Hence the snow lingers there much longer than on the southern slope, which, exposed to the more direct rays of the sun, is consequently warmer than the northern. It is for this reason that a poultry keeper builds his henhouse with the windows to the south, and with the sloping roof to the north, so as to get as much surface as possible exposed directly to the rays of the winter sun.

The Motions of the Earth.—We already know that the earth is spinning like a top, turning around once in what we call twenty-four hours, or a day, giving us daylight when our portion of the earth is directed toward the sun's rays, and darkness when we have the earth between us and the sun. The earth does not spin, however, exactly as a top, as its axis, or the central line about which it turns, is not vertical, but in a slanting position. Sometimes a top will spin for a moment about a slanting axis

just before it falls; then it is in a similar position to that of the earth at all times. On the earth, as on the top, the portion of the surface half-way between the stationary poles, or ends, of the axis moves more rapidly than any other portion, because the points along this line have to go farther in one revolution than any other portion. This half-way line of greatest motion is called the *equator*.

As the earth spins, it moves around the sun in a nearly circular course, much as a spinning top may move across the floor. Perhaps the motion can be illustrated better by floating an apple in a large pan of water, about some fixed object in the centre, representing the sun. If we have the apple in such a position that the line from the stem end to the bloom end is in a slanting position similar to the axis of the earth, the stem end standing for the North Pole of the earth and the opposite point for the South Pole, we can easily illustrate how the several parts of the earth lie with reference to the heat-giving sun.

It is easy to see that there is a broad belt on two sides of the equator within which the sun always shines vertically; that is, somewhere in this region the sun at noon would be directly overhead to one lying on his back and looking upward. The limits to this area on the earth are known as the *tropics*, from a Greek word meaning "to turn," because the sun seems at these limits to turn in its course, though, of course, it is the earth that changes in relation to the sun, rather than the sun in relation to the earth. The northern tropic is known as the Tropic of Cancer, and the southern as the Tropic of Capricorn.

Similarly, we can see that there are certain parts of the earth about the poles that are, during certain seasons, turned away from the sun, so that the earth cuts off

any rays of light and heat, just as in the night the earth itself cuts off the light from the portions in darkness. The limit to the north polar region within which the sun does not shine during some part of the year is known as the Arctic Circle, and the limit to the similar southern region is known as the Antarctic Circle. Between the circles and the tropics, in both the northern and southern hemispheres, lie the regions within some part of which the sun always shines, but never vertically. It should be noted, however, that when either polar region is all lighted, the area between the circle and the tropic receives its rays at a more direct angle than at other times, and that at that time the sun is vertical on that side of the equator.

Zones and Heat Belts.—Were all the heat that is received from the sun within these several areas of the earth retained at the place where it is received, the tropics and the circles would very naturally divide the world into five great climatic divisions, known as the tropical zone, the north and south temperate zones, and the frigid zones, each zone being a very definite and straight-edged belt about the earth, although it would be better to speak of the frigid zones as polar caps rather than as belts.

Inasmuch, however, as all parts of the world cannot retain the heat that comes to them with equal readiness, we find that the climatic divisions of the world are not quite so regular as the idea of zones would lead us to expect. The climatic divisions of the earth are known as heat belts, and are determined in their bounds, not by the amount of heat received, but, as has already been suggested, by the amount retained.

Were all portions of the earth capable of retaining heat

with equal ease, the temperature of a place would practically be determined by the angle at which the rays of the sun strike the earth at that spot. As a matter of fact, however, the heat absorbed by the earth in the daytime is to a large extent given out in the night, and that received and absorbed during the hot parts of the year is given out in the cold season.

Furthermore, the land areas of the world absorb heat more quickly, and give it out more quickly, than the water; that is, water once heated will stay warm longer than the rocks of the land, but it takes a longer time to warm the water than the land. The fact that land and water differ in their rate of absorbing heat explains the reason why the swimming season comes long after the ground is warm enough to sit on in the spring, and why the water is warm for swimming in the autumn when the air may be too cold for comfortable bathing. The same thing is shown by the present use of hot-water bottles rather than soapstones as a means of keeping one warm when riding or sleeping. It is for this reason that the lands are hotter in the summer and colder in the winter than the adjacent oceans, which receive from the sun the same amounts of heat. It is very evident, also, that no part of the world absorbs more heat than it afterwards gives out, for if it did, the world would be becoming warmer each year; or if it gave out more than it absorbed, it would be becoming colder.

When bodies of different temperatures are near to one another, there is a tendency for the temperature to become equally distributed. It is for this reason that the land and the water are giving up their heat to the adjoining air in the nights and winters, as has been suggested. Were the warm waters of the oceans to remain at rest

during the winter and summer seasons, they would undoubtedly be subjected to greater changes of temperature than they now are; but we have already seen that there are in each of the great oceans a series of ocean currents which are continually carrying the warmer waters from the tropical region polewards, and the colder waters from the polar regions toward the equator. This movement of the oceanic waters is the most important cause for the unequal distribution of temperatures over the world, inasmuch as some of the heat received in certain parts of the earth is carried to less favored places.

It is evident, therefore, that on the whole we should expect those regions at a distance from the equator to have an average climate colder than those regions near the equator; and furthermore, that in the equatorial regions the lands would be permanently warmer than the oceans, whereas in the temperate regions the lands would be warmer in the summer and cooler in the winter than the adjoining ocean. We have seen, also, that the movement of the ocean currents in the northern hemisphere is such that the westward sides of the continents are warmer than the eastern, being bathed by the warm ocean waters; so the fact that the world is made of land and water, and that the water is in motion, is an important cause for the variation of temperature in any zone.

The heavier, lower air in which we live is the warmer, and as one rises into the upper, lighter air, less heat is received from the earth. Hence we can get practically the same range in temperatures by climbing a high mountain in the tropics as we can by going from the tropics to the polar regions; and highlands are, as a rule, colder than the adjacent lowlands. This is beautifully illustrated along the line of the famous railway in Peru,

that goes from sea level to an altitude of over 15,000 feet, and thence down to about 12,000 feet. "The first part of the journey is through fields of sugar-cane and cotton; at 5,000 feet a zone of fruit trees is passed through; at 10,500 feet there is a district famous for its potatoes where little else is grown; above this the altitude is so great as to preclude the growth of anything but grass. At the highest point reached the snow lies on the mountain summits throughout the year, and the traveller may enjoy a snowstorm in the middle of summer (December–February). In the interior valley, farm produce is again seen growing. This whole succession of climates may be passed through in the short space of ten hours." *

The parts of the world in which the temperature is on the average below freezing—that is, less than 32° Fahrenheit—are spoken of as the cold belts. We have thus a northern and a southern cold belt. Where the temperature is on the average above freezing, and less than 68° Fahrenheit, it is known as the cool, or temperate belt; about the hottest regions of the world, where over the land, at least, the average temperature is above 80°, we have the hot belt; and between the hot and cool, or temperate belts, we have the warm, sometimes called the subtropical belt. These several belts are known as heat belts, and differ very much in their limits from the zones.

The division of the world into heat belts becomes more possible each year, as we learn more and more of the climatic conditions of the world as a whole.

It is possible, of course, to find out the average temperature conditions of any spot on the earth at which

* R. DeC. Ward, Climatic Notes made during a Voyage around South America, Jour. Sch. Geog., October, 1898, p. 309.

observation for temperature has been carried on for a long time. If we then represent these conditions on a map, and connect them by lines, we can by means of these lines indicate the position of all points having the same average temperature for any given time. Such lines are known as *isotherms* (equal heat), because all the points along them have equal temperatures. A study of the map showing the isotherms of the world for the year, or for the different seasons, will therefore tell us much in reference to the temperature and the other conditions depending upon temperature.

Were the sun's rays always vertical at the same point, there would be a line about the earth having the greatest average temperature, pretty nearly coinciding with the equator. As we have already seen, however, the sun in the summer season is shining vertically somewhere north of the equator, and in the winter season south of the equator; therefore, the line of places receiving the greatest amount of heat moves north or south with the change of season. The land areas would, for the several reasons we have already suggested, become much warmer than the water areas, and therefore, owing to the fact that there is much more land in the northern hemisphere than in the southern, we should find the extremely hot region extending farther north from the equator than south of it. This line of greatest heat is commonly called the *heat equator*, and on the average lies, for the reasons we have suggested, north rather than south of the equator, although in the northern winter it is mostly south of the equator. The region over which the heat equator swings during the year is commonly known as the hottest heat belt.

CHAPTER XVIII.

WINDS AND RAINFALL.

WE are all familiar with the upward movement of heated air and the downward movement of cold air in a room ; in order that this hot air may escape easily, we usually open a window at the top rather than at the bottom. We also know that air, being able to move with perfect ease, and the hotter air being on the top, the hot air is the lighter, and the cold air the heavier. In a similar way we should expect, on the whole, that the weight of the air, or, as we say, the *pressure*, would be less in those parts of the earth where the temperature is highest, and greater in the colder portions. We should also expect the air to be moving continually from the regions of greater pressure to the regions of lesser pressure, or from the two sides of the heat equator toward the heat equator.

The air from the two sides of the heat equator is continually moving in toward the region of low pressure, or of light air at the heat equator, the winds brought about by this movement being familiarly known as the *trade winds*. As the air rises when it reaches the heat equator, there would be no movement of air along the ground, or, as we say, no wind, but rather a calm in this region. This belt of calms, with its quiet, warm, breathless air, is well known to all travellers who have to cross the equator, and is a very perplexing and disagreeable feature to the master of a sailing-vessel, who depends upon

wind for his means of motion, and who may be detained for days, waiting for even a breath. This belt of *calms* about the equator, and closely coinciding with the heat equator, is familiarly known as the *doldrums*.

On the outer side, or toward the poles from the trade-wind belts, a little north and south from the tropics, we find a region where the air which has risen at the equator and started toward the poles begins to settle, thereby increasing the weight of the air in that region. In these two belts, known as the *horse latitudes*, the air being in motion vertically rather than along the ground, there are again calms, and from these two belts the air moves north and south toward the poles and the equator. Between the horse latitudes and the polar regions are two broad belts, in the northern one of which we live, which are known as the belts of the *stormy westerly winds*. Those winds in general blow from the southwest in this hemisphere, and from the northwest in the southern hemisphere, in which latter region they are much more persistent and strong, owing to the free and uninterrupted sweep they have over the waters of the southern ocean. From their position and their strength the southern westerly winds are commonly known as the *roaring forties*. Finally, about the poles we have a series of cold winds blowing outward from the poles, and commonly known as polar winds.

We have already seen that the several belts of temperature swing north and south with the apparent yearly motion of the sun, and in the same way we must expect the wind systems to swing north and south, so that certain parts of the world will be blown over by one system of winds in the summer, and another in winter. This feature is well illustrated in the southwestern United States,

where in winter the westerly winds prevail and in summer the trades.

In our own temperate regions the stormy westerly winds are interrupted in their force, particularly over the land, because of differences in temperature between the land and water. In the winter, when the land is so much colder than the water that St. Louis, New York City, and southern Iceland have practically the same temperatures, the air over the continents is not only much colder, but much heavier than over the ocean. Consequently our fair-weather winds blow outward from the continents to the oceans, as is well illustrated by the familiar winter northwest wind of the Eastern United States. In a similar way in the summer the winds blow from the oceans toward the land, the air on the land being lighter and warmer than that of the ocean.

This effect of land and water upon the movement of the air is well illustrated, at certain seasons of the year, along our eastern coast, by the change in direction of the winds during the daytime. In the morning the air over the land is colder and heavier than over the ocean, and hence the winds blow from the land to the sea; during the forenoon the air over the land gets warm faster than over the sea, so that about noon, or perhaps a little after noon, the air over the land is warmer and lighter than the ocean air. As a result, the colder air of the ocean moves in toward the land, giving us, in the season when such cool ocean air is agreeable, what we call a *sea breeze*. In the spring of the year, when this air chills us disagreeably, we commonly call it an east wind. The same change from night land breezes to day sea breezes frequently occurs on the borders of large lakes, so that the lake breeze of Chicago, for instance, does for

Chicago what the sea breeze does for New York and Boston.

This change of direction going on in a single day in certain parts of the year is but a small illustration of the great changes taking place during the whole year, between the continent fair-weather winds of winter and the ocean fair-weather winds of summer, which have already been mentioned. Besides these several systems of winds, each dependent upon differences of weight of the air, brought about by changes of temperature, we, in the so-called temperate regions, are subjected to very rapid changes of wind, and sometimes of weather, which are brought about by the severe storms which pass over us, interrupting the fair-weather conditions that we have for the larger part of the time.

Moisture and Rainfall.—The element in the weather of a region which determines what we call the character of the day is the moisture. It is moisture also that, next to temperature, makes the climate of certain regions endurable, and of others perhaps hardly bearable, and it is on the moisture and temperature that all growth of plants depends. Moisture exists in all air to a certain extent, in the form of invisible water vapor. Even in deserts the air is not wholly free from moisture, though it may seem to be to those who are suffering from the discomforts of the region. The fact that moisture in the air may be invisible is perhaps best shown by looking at the mouth of a rapidly boiling tea-kettle, and by noticing that for a certain distance from the mouth nothing can be seen, whereas beyond that we find a small cloud of what we call steam. Steam forms when the invisible vapor has cooled and accumulated in little drops that make clouds.

Moisture is taken up into the air from any wet surface, or, as we say, evaporated, through the influence of heat. Many hot-air furnaces, for instance, are supplied with pans for holding water to be evaporated and carried to the rooms above by the heated air, making the air more healthful and agreeable. It is the invisible moisture in the air that makes certain warm, so-called sultry days in the summer so unpleasant, and it is the moisture in the air in the winter that makes certain days so chilly and disagreeable. Hot air will include much more invisible vapor than cold air. Hence if warm air containing a large amount of moisture be chilled to a sufficient extent, the vapor will form into drops, or, as we say, condense; and if the amount be very much greater than what the air can hold, some of those drops become so large that they fall to the earth, under the pull of gravity, giving us rain or snow.

It is the moisture condensing at high levels in the air that forms clouds. When the air is full of fine drops of moisture down to the very surface of the earth, we have a mist; or if very thick, we call it a fog. In most nights of the summer, moisture condenses on the cool surface of the rocks, or the grass, or leaves, and we know it as *dew*. In a moist summer day the vapor of the atmosphere chills and forms dew on an ice pitcher, and in the winter the moisture of our breath forms a little cloud, or perhaps condenses and freezes as frost on the windows of our rooms, covering them deeply.

When the moisture in the air becomes so great that the drops fall to the earth, we have rain; if that water freezes in its descent, we may have snow, or possibly sleet, or, under exceptional conditions, large lumps of ice, which we call hailstones, may be formed in the air.

It has already been noted that moisture may be evaporated from any part of the earth's surface which is wet. The oceans and larger lakes of course supply the greater proportion of the moisture, and very naturally it is the water in the hot belts of the earth that is taken up most rapidly into the air. In any case the moisture of course is carried by the prevailing winds, and any conditions over the land which cause the winds to be chilled as they move, bring about rainfall.

The larger cause for rainfall over the land is due to the fact that the land is rugged, and that the air must rise to move across the continents. As the air rises, it cools rapidly, as we have already seen, and hence loses its power for carrying moisture. As a result, heavy rainfalls occur in those parts of the world where the prevailing winds blow from water to land, and where mountain ranges are found close to the sea. For instance, the rainy portion of the United States is in Washington, Oregon, and southern Alaska, where the Coast Range causes the moisture-bringing wind to supply an abundant rainfall, a large part of this coast receiving more than 75 inches of rain on every square inch of surface during the year. In 1899 certain parts of the coast of Oregon received more than 100 inches.

The same effects of highlands upon rainfall are shown in South America. In the trade-wind belt the wind blows from the Atlantic Ocean across the continent, and is not forced to rise to any great height until it comes to the western side of the Amazon Basin, at the foot of the Andes Mountains. As a result, the Amazon Basin and the Eastern Andes have a heavy rainfall, it being more than 80 inches a year, whereas the coast strip on the western side of the Andes is practically dry. As we go

farther south, particularly into southern Chile, where we find the westerly winds striking the Pacific side of the Andes, we again have a heavy rainfall; whereas the country on the leeward side of the highlands is again practically a desert, some parts of it receiving less than ten inches of rainfall during a year. A similar illustration of the effect of highlands on rainfall is shown in the highlands of Brazil along the southeast coast, where we find the rainfall again more than 75 inches.

Deserts and Arid Regions.—The fact that regions on the leeward sides of mountain ranges are usually dry is beautifully illustrated in the southwestern United States, just east of the Sierra Nevada Mountains, and west of the so-called Rocky Mountains, where the rainfall is less than ten inches, and in some places less than five inches a year. Yuma, Arizona, in the Yuma Desert, received less than an inch of rain in 1899. Perhaps the best illustration in the world is shown in Australia, where the eastern highlands receive a rainfall amounting in places to nearly 75 inches in a year, while the interior region is one great desert, with so little rainfall that certain parts of it are practically unexplored, even at the present time.

As a rule, therefore, we may say that the windward sides of continents are moist, and the leeward sides dry, although there is a certain apparent exception to this in the eastern United States, which has an abundant and sufficient amount of rainfall for all purposes of agriculture and life. The moisture here, however, is brought from the Gulf of Mexico and the Great Lakes, in part by the prevailing winds and in part by the storms.

When winds blow from a cold to a warm region, and at the same time blow across the land to get to that

warm region, they not only become better able to carry moisture in an invisible form, but, blowing over a region that can furnish but little moisture, they leave that region much drier than they found it; or, in other words, turn it into a desert. The best illustration that we have of this manner of forming deserts is perhaps shown in the case of the Sahara, the same distance from the equator as our own well-watered Florida and the eastern coast of Central America. The winds that cross the Sahara on their way to the heat equator are dry when they start from the horse-latitude belt. Originating as they do over the land, they become more and more dry as they become warmer and warmer, and hence better able to hold moisture. In Central America, on the contrary, the trades, coming from over the ocean, have their moisture supplied to them as rapidly as they need it, and when they reach the land, naturally furnish a large supply of rainfall. Were the Atlantic Ocean a land surface, Central America would be as dry as the Sahara, and were the continent of Eurasia a body of water, the Sahara would have as heavy a rainfall as Central America.

The ability of the warming winds to take moisture from the water is well shown by the fact that the trade-wind belts of the oceans are salter than are the oceans to the north and south. This is due, of course, to the fact that the moisture evaporated is pure water, which leaves behind the salt, making the water that remains more salt than it would otherwise be.

Rainfall of the World.—In looking at the rainfall of the world as a whole, we find certain striking relations to the several heat belts that have been mentioned. The cold belt in the northern hemisphere, the only hemisphere in which there is any large amount of land in that

belt, has a small annual rainfall, owing in part to the fact that cold air cannot evaporate moisture rapidly. We find thus that northern British America, Greenland, and Siberia have a rainfall of less than ten inches a year, and that except on the coast of both North America and Eurasia, as far south as the trade-wind belt, the rainfall is small, deserts being a conspicuous feature in the interior of the continents on the leeward side of the mountain ranges. The same thing holds true in southern South America, the only continent in the southern hemisphere that reaches really into the cool belt.

In the warm belts we find a large amount of desert shown in the southwestern United States, in the Sahara, in Arabia, in Persia, and in the Desert of Gobi in northern Tibet. The same fact is shown in southern Argentina, in southwest Africa, and in Australia. In the hot belts we find the regions of the great rainfalls of the world. The greatest rainfall known is at Cherra Punjie, India, where it reaches 493 inches, or something over 40 feet in a year. A fall of 40.8 inches occurred at this place in one day, on June 14, 1876, this being almost equal to the amount that ordinarily falls during a year in New York City, which usually receives about 46 inches a year. In the doldrum belts of the world the rain is almost daily in its occurrence.

CHAPTER XIX.

CLIMATE OF THE WORLD.

Seasons.—In any of the climatic or heat belts the weather changes, in a general way, with the seasons, and in describing the climate of these several regions it is necessary to take these changes into consideration. In the cold and cool belts we have four seasons, the more important being, of course, the winters, in which the region is cold, and the summers, when the countries are warm, reaching at certain times, for a few days, very high temperatures. In the warm belts we have cool winters and hot summers; and in the hot belts, within which the heat equator lies for the whole year, the temperature is always hot. In this latter belt and, indeed, in a portion of the warm belts we have two seasons, brought about not by differences of temperature, but by differences of rainfall. When any given region in these areas is occupied by the heat equator, we have the rainy season, and when it is not occupied, the dry season. In the northern and southern portions of the belt, therefore, near to the tropics, there are two seasons, one rainy and one dry, the rainy occurring when the sun is vertical, and the dry when the sun is vertical in the region of the other tropic. In the equatorial region, where the sun is vertical twice a year (March and September), instead of one we have, naturally, two rainy seasons, separated by two dry seasons.

Summary.—In the hot belt there is in general a high and constant temperature, accompanied by a heavy rainfall and a great amount of moisture in the air. The climate is thus uncomfortable for white men, owing to the excessive moisture and the high temperatures, and also in part owing to the fevers that are found to be so common a feature of the torrid regions. Negroes and certain other races of men find in these torrid and, to us, uncomfortable regions the very conditions favorable for their life, and thus we find the larger part of these regions occupied by primitive peoples. Over the low-lying areas the temperatures and moisture are favorable for the development of luxuriant vegetation, like that of the famous tropical forests of the Amazon and of Central America. Associated with the men and the plants we find the beautiful tropical birds, and the heat-loving tropical animals, many of them large and unwieldy, like the crocodile and hippopotamus.

In the warm belts we find, as we have seen, two seasons, the wet having practically all the discomforts of the tropics, and the dry being comfortable and agreeable. In this region we have the savannas, in which during the rainy season there is a luxuriance of vegetation, particularly of the grasses, which dry and wither in the following dry seasons. The savanna area is found in Brazil around the Orinoco, in Central America, in the Sudan, about the headwaters of the Nile in Africa, and in northern Australia.

In those portions of the warm belt that are excessively dry we have, of course, the characteristic absence of vegetation of the desert, with its further scarcity of population. In the cool belts of the temperate zones we have in the southern portions the forests and the grassy

steppes, illustrated by the prairies of North America and the forests of our Eastern States. In the northern portion we find abundant forests, mostly, however, of coniferous trees, growing smaller and smaller as they ap-

FIG. 83.—A VIEW IN THE TUNDRA REGION IN ALASKA, SHOWING CHARACTER OF VEGETATION.

proach the polar regions. These northern regions of the cool belt, particularly on the eastern side of North America and Asia, and on the western side of Europe, are the most densely populated regions of the world. This is in part due to the favorable, though changeable

climate, to the rainfall, and to the conditions that make the growth of cereals and other food-giving crops easy and successful.

In the northern polar regions we have the tundra (see Fig. 83), known in North America as the barren grounds. Crops will not grow here; the principal forms of vegetation being the mosses and lichens which almost cover the ground during the short summer. This tundra region is, of course, frozen during a large part of the year; and in the extreme north, nothing but snow and ice can be seen. Hence these regions, like the deserts of the warm belt, are practically without any inhabitants, a very large proportion of the area having less than one inhabitant to the square mile, whereas in certain portions of China and India there are approximately 500 inhabitants to the square mile.

The northern temperate region, inasmuch as it contains a larger part of the healthful, inhabitable part of the world, is therefore the region occupied by the most dense population. It is also the region where the conditions of climate tend to make a man active rather than inactive, and in which, therefore, we find the progressive nations of the world, as is perhaps best shown by noting the position of the United States and southern Canada, of England, France, and Germany, and of Japan, in reference to the heat belts.

OTHER IMPORTANT PHYSICAL FEATURES INFLUENCING MAN.

CHAPTER XX.

SOILS.

IT has sometimes been said that, were a man from the planet Mars to land on the Earth, with the thought of making his home here, he would at once ask several practical questions in reference to the parts of the earth in which he could live without too great difficulty or labor. Were such a thing possible, such a man would undoubtedly come to us with an understanding of the way a planet is divided into great climatic belts, habitable or uninhabitable according to the distribution of temperature over the planet. With this information in mind, he would undoubtedly first ask as to the character of the country in each of the climatic divisions, for he would want to know, for instance, whether there were mountains in the torrid portions of the earth that would enable him to find temperate conditions there; he would want to know something about the topography of the larger temperate belts of the earth, that he might be informed whether the country were available for agriculture, or manufacturing, or some other industry.

A knowledge of the climate, then, would enable him to find some large area in the world agreeable to him;

a knowledge of the topography of the region would perhaps enable him to choose some particular locality in that area. In order to be able to choose his home with exactness, he would, however, have to find out a number of other matters. He would want to know something of the soils; something as to the supply of water; as to the means of defence; the ease of transportation; as to whether there were natural power, and natural products that would give him the materials for a sheltering house, for his necessary utensils, for his clothing, and for his food. These are some of the other matters, all of them more or less geographical in their distribution or character, that help determine whether men can live in different parts of the world, and if they can live there, their occupations and customs.

In any region the character of the topography has a great influence upon the distribution and the character of the life throughout the country. This applies, of course, more particularly to the temperate region, in which the progressive nations of the world live. The highlands we found to be regions of steep slope, of cooler climate, usually of thin soil, and in some cases covered continually with snow; their windward sides wet and perhaps habitable, their leeward sides dry and barren. From their height and their extent they are apt to be great barriers, making migration and cross-country travelling difficult. Thus, as a rule, highlands are isolated regions, except where they contain minerals, or bear forests, of profit to man.

In striking contrast to the highlands, we found that lowlands were generally favorable to life. Their gentle slope, their deeper and richer soil, their abundant water supply, if situated favorably as to climate, and, in gen-

eral, their larger and more navigable rivers are some of the features which make these regions desirable for homes. As we found the windward side of highlands habitable, so we find that lowlands on the windward side of continents are generally favorable to life; whereas those in the interior, or in the trade-wind belt, as in the case of the Sahara, may be anything but habitable.

In any region we found the character of the slopes important. Where the slopes are steep, the soil is apt to be thin, and grazing and lumbering, rather than agriculture, are the occupations. The steepest slopes are given over to waste regions, perhaps occupied only by climbing animals and stunted trees. The streams of such a region are swift and small, and the water that falls will run off at once, perhaps swelling the streams to a flood.

In the regions of gentle slope we found other occupations, and more particularly those of agriculture and manufacturing, to be the most successful, owing in part to the depth of soil, the abundance of water, and to the ease of cross-country travelling. In the gentle slopes of the great plains and prairies of the world were formerly to be found the nomadic and perhaps warlike tribes of primitive people, which have now, at least in North America, so largely given way to the more advanced races.

Agriculture is the most important industry of the world; for as all men must eat in order to live, it is evidently of the utmost importance that food be provided. Men live either on the vegetable products of the soil, or the flesh of animals that have lived on these products. The conditions, therefore, that make agriculture possible in a region are very important. The character of the soil, then, is the third, perhaps, in impor-

tance of the several things that influence man in his distribution.

Soils are made mostly from the weathered and decayed rocks of the earth, although all valuable soils contain a certain amount of decayed animal or vegetable matter. Any weathering rock-surface shows us soil in the making, and the mosses and lichens that grow perhaps on a strong rock surface that has weathered but little aid in the deepening and enriching of the soil. Soils are not of value, however, until they are sufficiently deep to support the larger crops.

Kinds of Soils.—The soils of the world may roughly be divided into two great groups, according to the way the materials of that soil have been accumulated. We may have a soil which has been formed by the decaying of the rock on which it lies, or we may have a soil the particles of which have been brought from very many places, and perhaps from a great distance. Of the latter group the more important are the soils carried along and finally deposited either by the rivers, the wind, or by moving ice. In the northern United States the latter class are the most important, for all the land of the area formerly covered by the ice, which we have already outlined, is covered by soils brought to their present position by the great ice-sheet. In some cases the soils are thick, and in some cases they are very thin. Their richness depends upon their depth, and also upon whether they were deposited by the ice itself, when they are more or less clayey and fertile, or by the water which ran from beneath the ice, when they are usually sandy. Of this latter character are the soils of southern Long Island and Staten Island; the soils found among the ledges on the heights and in the parks of Greater New

York, and on the higher hilltops of New England, are ice-brought clayey soils, and are extremely rich, although they often cover but a small area.

The most important group of soils, taking the world as a whole, however, is perhaps the river-made soil, such as is found in the great alluvial plains of the world, and along the lower courses of most rivers. In order for a soil to be valuable, it must be made of fine materials, and should contain just as many different kinds of materials as possible. River and ice made soils are rich for both of these reasons. In each case the materials are very fine, and further, there are many different kinds of rock in each soil, because the rivers or ice bring soil materials from so many different rock ledges and hillsides up-stream.

The third kind of soil, made from materials brought from a great distance, and from very many places, is that accumulated by the wind. In the sand-dunes of our seashores and deserts we have excellent examples of such sand-accumulations, usually, however, not available for plant life, owing to their sandy character, and to the fact that they are so porous that water runs through them easily, and is not retained for the use of the plant. The loess deposits we have already mentioned are, however, much more fertile.

Outside of the regions where the ice, running water, or the wind has deposited any materials, which, of course, include the larger part of the earth, we have soils made entirely of the weathering of the underlying rocks, and hence depending for their character on the kind of rocks from which they have been formed. If those rocks are strong and contain a large amount of quartz, such as sandstone, the soil formed therefrom will

probably be poor, as the rock materials are not very easily dissolved. If, on the other hand, the rock is easily eroded, and particularly if it contain lime, as do limestones, the soil will be rich. Soils formed by the weathering and rusting of the rocks have a rusty red color, varying from a reddish yellow to a deep dark crimson. Limestone soils are, perhaps, the best of the great group of soils made in this way, the limestone soils of the Shenandoah and Tennessee valleys being famous for their fertility and richness. Soils formed from volcanic rocks, or from granites, are usually rich, although it should be noted that it takes a very long time for rocks of this class to weather into soils. Yet, as a matter of fact, there are areas of the world in which the granite soils are several hundred feet deep; that is, where one would have to dig down into the earth for perhaps four hundred feet to reach any solid, unweathered rock.

In almost any exposure of soil, brought to light by cutting into a decomposing rock hill, for instance, we find a certain series of soil characteristics in a very definite order, as we descend into the earth. At the top there are usually a few inches of dark, perhaps almost black soil, of a very fine character, containing a large amount of decomposed plant materials; beneath this we find the plant remains less conspicuous, and the particles of soil larger, the rusty color standing out more prominently in consequence. Perhaps at a depth of ten or twelve feet we may be able to see that the rock was once a continuous mass, afterwards broken into great blocks, the edges and sides of which have weathered and rusted, until now we have a series of rounded boulders, between which lie the finer soil particles. At some distance below this would come the solid rock.

Fertility of Soils.—The fertility of any soil is determined by the kind of materials of which it is made and by the fineness of the particles. Whether a soil can be used or not depends upon certain other things, primarily upon its position in the heat belts. The soils of the Mackenzie River are naturally just as rich as those of any other great river valley, but they are in a region too cold to be of any value for agriculture. The soils of the Amazon are as rich as those of the Nile, or the Euphrates, or the Yangtse-kiang, but they occur in a region too hot and too wet to be available for agriculture, though they support a most luxuriant tropical vegetation. In contrast to this we have our own Mississippi River, flowing from a cold into a warm, but not a hot region, with its rich alluvial soil in a favorable climate.

Another question that determines whether a soil will be of value is, of course, the presence of water. As has already been suggested, a rainfall of eighteen or twenty inches a year is necessary for agriculture. If the rainfall is but a little less than that, giving us a semi-arid climate, crops can, perhaps, be grown once in every few years; if much less than this, as in deserts, agriculture is impossible unless the region be irrigated, or artificially watered.

Certain crops take certain products from the soil, and others take other materials; therefore a farmer does not plant potatoes or corn on the same area year after year, but perhaps plants corn one year and potatoes the next, and then allows grass to grow for a few years, or, as we say, he rotates his crops, in order to make use of all the different contents of the soil without using up all of any particular thing. In this way soils may be kept from wearing out, and may be of service for the raising of crops year after year. A successful farmer, however,

does not depend upon his crop getting from the soil all the material it needs, but adds to the soil a certain amount of fertilizer, which makes the crops grow more rapidly and saves the soil from being made too poor by the growth of the plants.

CHAPTER XXI.

WATER SUPPLY.

THE water supply is another of the very important features that determines whether a region will be habitable or not. Not only must there be a continual supply of water in the soil for the use of plants, but there must be surface water for drinking and bathing purposes, for animals and men. That water must also be free from impurities which make it distasteful or unfit for use. In some parts of the world there is plenty of water, but it is so full of certain minerals dissolved from the soil that in some cases it is poisonous both to plants and animals. In other cases the water may be full of minerals, making it disagreeable for every-day use, but of value for invalids; such, for instance, is the sulphur water at Avon Springs, in central New York, and the many different mineral waters, some cold and some warm, found at Saratoga, New York.

In any region in which the rainfall is as great as it is in the eastern United States, there is plenty of water for most purposes, the amount, however, varying with the season, and somewhat with the ability of the rocks underneath the soil to keep the water from soaking through and running to the rivers too rapidly. A clay rock will retain more water than a sand rock, and therefore usually furnishes a better water supply, without difficulty. The amount of water in the soil depends largely upon whether the water of a rain runs immediately to the ocean through

the rivers, or whether it soaks into the ground, and moves toward the sea slowly, thus lasting a long time. In regions where the hill slopes are bare of trees, particularly around the headwaters of streams, the larger part of the water that falls in any storm runs off immediately, producing freshets in the streams, followed by a period of low water, or a drouth. Hence the advantage of keeping a certain part of a region forested, for in a forest-covered area the soft, spongy mat of decaying leaves and wood lying beneath the trees holds the moisture, and is always damp. That water soaks slowly through the rocks is also shown by the fact that in a forested area we find but little erosion of the country by streams; there are few tributaries to any large stream, and but little evidence of stream work.

Springs and Wells.—The underground water must, of course, be brought to the surface to be of use, at least for those people who occupy land on the hillsides, and away from the river valleys. In the upper portion of river valleys a part of the water may easily be made to turn off into a little trench or ditch, and run along the side of the hills at a more gentle slope than the main stream follows in the valley below. Thus the water may be brought out upon the land of the hillside farms and used there, either to water the land or to turn wheels of mills. This is the method of securing water frequently employed in those parts of our arid Western plains where there are few large rivers, and where irrigation is necessary to produce crops on the slopes. (See Fig. 84.) The success of this means of watering the land is very evident in an irrigated region, where the part that has been watered is beautifully green, while the area, perhaps but a few feet away, which has not been supplied

with water is dry, and as barren as a city street. (See Fig. 85.)

The most common way in which underground water is brought to the surface is through natural springs. Springs occur wherever some underlying mass of rock, through which the water cannot easily soak, comes to

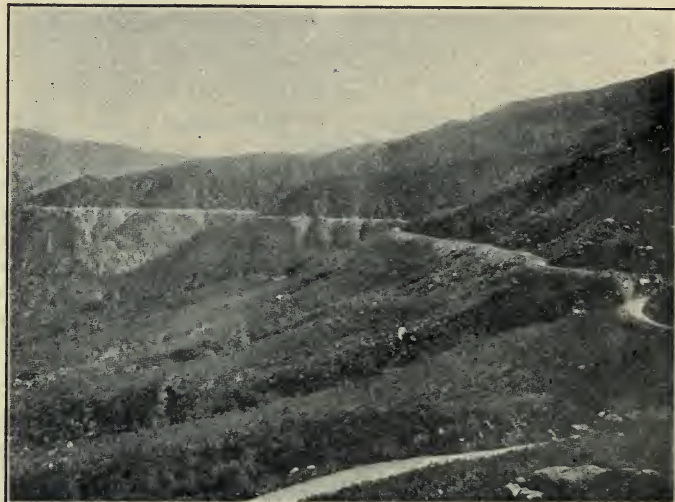

FIG. 84.—AN IRRIGATION DITCH IN CALIFORNIA, BUILT ALONG A HILLSIDE WITH A GENTLE SLOPE.

the surface. The water which has soaked down to the rock surface follows it, and appears at the surface of the land when the rock appears. (See Fig. 86.) In New England and certain parts of New York, where the soils are thin and where the underlying hard rock is not easily penetrated by the water, springs formed in this way are very numerous. In the hills of Massachusetts and Connecticut the roadside springs, which have been cleaned

and fitted up for the use of travellers, either animals or men, make travelling a pleasure and a comfort. Springs are also important as being the sources of rivers, each spring or wet spot on a hillside or in a valley being one of the perhaps thousands of little feeders that supply the stream. Rivers cannot therefore be said to have but one source. They have too many to count.

Outside of large cities, the customary way of getting

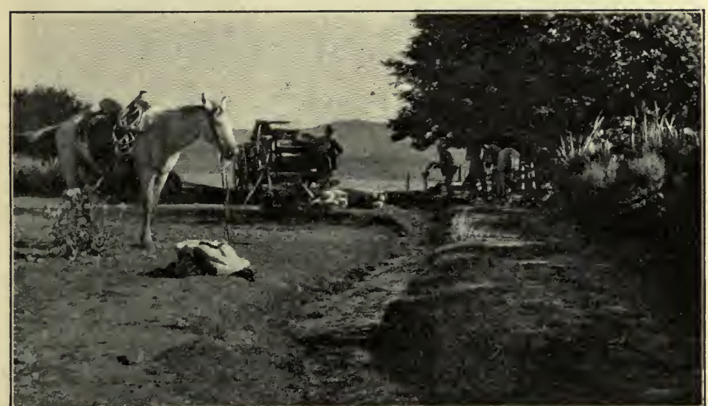

FIG. 85.—AN IRRIGATED TOWN IN UTAH. THE DISTANT HILLS ARE IN THE UNIRRIGATED REGION AND VERY BARREN.

underground water for house and farm use is through wells. A well is a hole dug down into the earth deep enough to reach some of the water that is trickling through the soil. The water is then raised or pumped to the surface and used. In former times many of the villages of New England had but one well, to which all the inhabitants went for their drinking water, driving their cattle to the more distant streams. In some places we still find such a town well, located in the centre of

the village, convenient to every one, and usually known as the town pump. In certain parts of our Southern States we find the little villages or settlements, perhaps of only two or three houses, located around a good

FIG. 86.—SPRING HIGH UP ON MT. MAZAMA, OREGON.

spring. In such cases it was the presence of the spring that determined the location of the little town, while in New England the town pump was placed after the town was started, the town being determined in its position by some other cause.

Where large supplies of water need to be secured from a well, the water is pumped out by steam, or by the wind, as may be seen on many of the large farms of New York and the Central States, where windmills supply water for large herds of cattle, and running water for the many buildings of the farms. In the ranching country

FIG. 87.—A FLOODED RIVER VALLEY FORMING A RESERVOIR IN CONNECTICUT.

of our Western plains, where trees are absent, we sometimes see occasional windmills that supply water for the cattle, the mills rising to a height of but a few feet, being, however, very conspicuous objects in the landscape, and visible for miles in every direction.

In still other cases, the supplies of underground water are so very deep beneath the surface of the earth that what are known as *artesian* wells have to be dug. (See

Fig. 18.) An artesian well is a hole dug or bored into the earth, possibly for several hundred feet, until finally a supply of water is reached, which rises through the hole perhaps to the very surface of the earth, or at least high enough to be pumped out. Artesian wells make possible the water supply of cities and summer resorts built on sandy beaches far from land, such as Atlantic City, New Jersey, for instance. In some cases the water of rivers is accumulated in a natural or artificial lake, making a great reservoir, the contents of which can be used as one wishes. (See Fig. 87.) The water from such reservoirs is often carried through pipes for long distances, and supplied to large cities, as the water from Croton River is carried to New York City.

In the early exploration of this country the presence of accessible water determined the location of towns in a good many cases, and in still more cases it was the presence or absence of water that separated the region first occupied from that occupied at a later date. At the present time even, the cross-country trails in the arid plains have all been chosen and determined in their direction by the presence of little pools of water that will furnish a supply sufficient for the traveller. A traveller not only follows the trail which takes him by the water, but, when it is possible to do so, arranges his journey in such a way that he will stop at night where this necessary is to be found. When he crosses a long stretch of country where no water can be obtained, he must carry a supply with him. As a matter of fact, the keg or canteen of water is as important a part of the traveller's outfit in an arid country as is the horse that carries him.

CHAPTER XXII.

DEFENCE AND NATURAL PRODUCTS.

A NEW settler, having found a land in which the climate, topography, good soils, and a water supply favored his building a home, would next have to consider the means of defence from his natural enemies, whether they be animals or men, and he would have to take advantage of all the natural features in the region that would make the defence easy. In the different parts of the world, particularly among primitive peoples, we find the life of the inhabitants of a country very largely influenced by the manner in which they defend themselves. In some ways the most interesting peoples, from the standpoint of defence, are the wandering or nomadic tribes of great plains, such as the Arabs of the deserts of Arabia and Sahara, and our American Indians, who formerly occupied the great prairies. Such peoples find on plains the food for their cattle and horses and all the necessaries of life. They live a life that allows them to move quickly from place to place, as their flocks have to move to new feeding grounds, and, further, that allows them to flee quickly if they are suddenly attacked by an enemy superior to them in numbers.

Nomadic people depend largely for their defence upon the fact that they can see their enemies at a great distance, owing to the character of the country, thus having plenty of opportunity for flight, if flight is

necessary. From the habit of being continually on the watch for anything moving in the landscape, and from long training, they have become able to recognize an enemy when he is far away. Thus peoples like our American Indians have gained a reputation for wonderful sight, whereas, as a matter of fact, they see no more clearly than a white man would see. They have, however, trained themselves to know a cloud of dust raised by an enemy or by horses from a wind cloud, when the white man might be unable to distinguish between them.

The people who live in mountains, however, have perhaps made the best use of their natural means of defence. Living in the lower valleys, or on the hill slopes bordering the streams, enemies can come upon them in but few directions, either up the valley or down the slopes from the head of the river, having come from a neighboring valley over the pass across the divide. Thus the people can defend themselves by defending the inlets to their home, and a few sentinels on the hilltops can very readily warn all the inhabitants of an approaching stranger in plenty of time for any necessary preparation to resist an enemy. Mountain peoples living in isolated villages in single valleys have but little opportunity to mingle with their neighbors, and come to have many peculiar ways, perhaps very different from those of their neighbors in the next valley. We see this development of isolated communities in separate valleys in certain parts of our Southern States, as, for instance, in Kentucky and Tennessee, where the people living in the flat-bottomed river valleys that run back along the streams between the high but perhaps narrow ridges on either side, being isolated in these small coves, know but little of the outside world or their neighbors. Such conditions of country and the

manner of life favor the continuance of the family feuds, or perpetual quarrels, for which this region is notorious.

Another way in which primitive peoples defend themselves is by building their houses in a spot naturally protected and somewhat inaccessible. In Arizona and New Mexico there are great numbers of so-called cliff houses

FIG. 88.—A CLIFF HOUSE IN A NEW MEXICO CAÑON FAR ABOVE THE VALLEY FLOOR.

built up on the sides of the steep-walled valleys in little niches under an overhanging ledge of rock. (See Fig. 88.) In such a case, attack is impossible from above, and difficult from below, as perhaps the paths leading up to the houses are very few and very difficult to climb. Cliff houses still remain in this region, showing the former

presence of great numbers of people, but the people have all gone.

In certain parts of China, however, we do have cliff dwellers at the present time, where the people have dug little caves in the sides of the steep cliffs, as a swallow digs a hole into a sand-bank. A traveller going through such a region might think the country uninhabited, seeing not a soul; and yet perhaps the country contains thousands of people, all of whom have fled into their little burrows on the sight of a supposed enemy, very much as rabbits disappear when they see a dog.

Primitive peoples sometimes protect themselves, too, by building their homes out in lakes, where they cannot readily be reached from the shore. Formerly large numbers of these lake dwellers lived in Switzerland, and in Lake Titicaca in South America, and now such lake houses are known in many places, among others in the Philippines.

In most regions of the world, however, natural protection is not readily afforded; therefore the first duty of the early settler, as was illustrated in the settlement of New England and Virginia, is the building of the stockade, or walled town, and the establishing of a body of defenders known as the militia. The stockade was in reality a wooden fence that, for a time at least, kept off the Indians, in case of attack, and enabled the early settlers to protect their flocks and herds from the attacks of wild animals at night. We see the same principle of the walled town in the building of a fort on the highest and most easily protected spot in many towns, to which the inhabitants can flee in time of danger, and again in the ancient and famous castles of Europe, in which the master lived, and around which, in the time of trouble, he gath-

ered all the people dependent upon him. We see, again, the same means of defence adopted in our arid Western plains, where walled towns, large enough to hold in some cases a great many hundreds of people, were once built either on some isolated hilltop, as are the present villages of the Moki and Zuñi Indians in Arizona, or perhaps out in the open plain, as is illustrated by many of the ancient pueblo villages now, like the cliff houses, deserted by their former inhabitants. (See Fig. 89.)

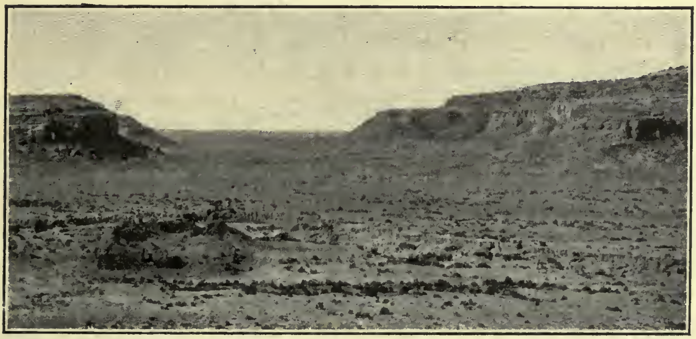

FIG. 89.—RUINS OF A PUEBLO TOWN IN NEW MEXICO. AN INTERMITTENT STREAM RUNS CLOSE BESIDE THE PUEBLO IN THE CAÑON SHOWN.

A region that will progress the most rapidly, other conditions being favorable, is that region in which the energies of the people can be devoted to their industries with the least thought of defence. Towns and first settlements are usually placed, if possible, in the most readily defended position. The early settlers who came to Virginia were warned before they came, to build their houses in an open place, sufficiently distant from the woods, so that the Indians could neither get together without being seen, nor throw arrows or other implements into

the town from behind some natural shelter. Thus clearings were made, and the wood of the cut trees was used in making the houses and the stockades. In our Western plains the early settlers could not readily protect themselves, and hence settlement was slow and dangerous, and the Indian inhabitants were a continual menace to the unprotected people until within a very few years.

Natural Products.—Having established a home and gained the necessary means for life from the soil, the new inhabitant naturally looks about him to see what else the region affords that will aid in making his life more successful. In modern times it is often the natural products of the earth that lead men into new regions, as recently men have been attracted to the gold fields of Alaska. But in early times the use of the natural products very largely came after the settlement of the region. Man must have not only food, but shelter and clothing, and therefore a region will develop most rapidly in which the best opportunity is afforded for the easy getting of these necessaries of life.

The American Indian used skin or stone, or possibly clay, to make his home, gathering the skins from the animals of the chase, and using clay or stone only in the more permanent winter home, as do the Navaho Indians at the present time. White men, as a rule, use wood for their homes, and the opening up of some regions is largely hampered by the absence of forests capable of furnishing wood for building and for utensils. The most important of the natural products that are at present gathered from the earth for building purposes is iron. This is now one of the most used minerals of the world, not only for building purposes, but in all the arts and industries.

Man gathers his materials for clothing very largely from the skins of animals, either in the form of the skin or of the wool, which is made into cloth, or else he raises cotton or flax, and weaves his cloth from these commodities. In the early development of this country, men carried their clothing with them for the most part. Except in case of great need they made use of the skins of animals only for certain purposes, such as the making of moccasins.

Besides the need for food, clothing, and shelter, supplied in part, as we have seen, through agricultural, and in part through the natural products of the earth, man needs materials for giving him light and heat, the latter particularly for cooking, and, in modern times, for the creation of steam. Formerly heat was gotten largely from forests, through the burning of the wood, and thus homes established in an open country were established under difficulty. Light was obtained from the fat of animals, such as the sheep, or later from oil gathered from the whales. At present a large supply of the light and heat of the world comes from the deposits of coal, of oil, of gas, buried in the depths of the earth. The mining of these commodities has become, as we have already seen, one of the important industries of the world, and the distribution of these several things has made certain parts of our own country develop with great rapidity.

Another great need of civilized and of uncivilized men is materials for making utensils of all kinds and for implements of warfare. Iron, tin, and copper have come to be of very great importance to modern man; but in the early time it was the presence of rocks, of wood, or of clay, perhaps, which made one nation

superior to another. The Indian tribes of North America that occupied a region containing an abundance of clay for their necessary water-jars and other cooking utensils, and plenty of rocks of the proper quality to make arrow-heads and spears, had a great advantage over their neighbors, and undoubtedly profited greatly by exchanging their riches with their neighboring tribes, getting in return other things which they needed but could not make. An arrow or spear head found, at the present time, many miles from the kind of rock of which it was made, is a very good witness of trade between tribes if we know from other reasons that the two regions were occupied by different peoples.

In modern times two metals have come to be of very great value, partly because of their rarity and partly because they are so indestructible. These two metals are gold and silver, of which the larger part of the money used in trade is made. The seeking of these metals, particularly gold, has been the cause of the settlement, and, indeed, of the discovery of the valuable features of certain countries. It was gold that first attracted men to California in 1849; but many of the settlers, attracted first by the gold, remained to establish one of the greatest and richest States of the Union, having found other features of great value.

There are other natural products to be gathered from the rocks, in the primitive forests, or from the wild animals, that have come to be of very great value, although their former use was never sufficiently great to have their presence determine the rapid development of a region. We find good illustrations of this in the deposits of phosphate in Georgia and Florida, which are now being extensively used for fertilizers in farming, but which once

were not considered worth anything. Among other products are those used for medicines, like the bark of the cinchona tree, giving us our quinine, or those used for more general purposes, of which we have a very excellent illustration in the rubber obtained from the juice of the rubber tree.

With the development of peoples new uses are discovered for commodities once wasted, and thus new reasons are being brought forward continually for the development of new regions. These regions, perhaps, offer no particular advantages for civilization, other than the presence of some particular deposit or material, like those mentioned. When this material is exhausted, the region will again be deserted, unless some other advantages of importance be later discovered.

A knowledge of the distribution of the natural products of the earth, and sufficient energy to secure these products, have made possible the commercial progress of certain nations. The development of the extensive and widespread colonies of Great Britain, for instance, has been in part due to the fact that the English have been among the first to push into new regions, and to recognize the value of the natural products of those countries.

CHAPTER XXIII.

TRANSPORTATION AND POWER.

WE have already seen that even the most primitive people are, as a rule, not wholly dependent upon themselves and their own locality for the necessaries of life. When any people have more of any valuable commodity than they need, and lack other commodities, it is very natural that trade or commerce should follow. Early commerce consisted of the direct exchange of one material for another, as one boy swaps marbles or jack-knives with another. As trade is developed among peoples, the need of some indestructible material, like gold and silver, that should stand for certain wealth has caused barter to give way to trade, in which money is used. Trade is not confined any longer to neighbors in the same town or village, but takes place between peoples and nations of the most remote parts of the world. Trade or commerce of all kinds, therefore, demands the intermingling of peoples, and has necessitated ready means of transportation over the lands and the oceans. The land trails of the Indian traveller and hunter gave way to the road later occupied by the stage coach. This in turn has largely been replaced by the railroads.

In each case the line of communication has been along the most accessible route that makes rapid migration possible. Natural highways, therefore, such as the Mohawk Valley, already mentioned, have come to be the great connecting links between different parts of the

country. Canals and river boats have again followed the natural lines of commerce, all determined by the geographic conditions. The country therefore having the best facilities for the development of railroads and canals, and the most navigable rivers, has the best chance for sending out its products rapidly, and for getting in return, at low cost, the products of the rest of the world.

The world commerce, however, demands still larger means of communication, and more natural conditions favorable to shipping. Good harbors are thus an essential part of any progressive nation, and the leading nations of the world are continually struggling for good harbors in the different parts of the world. The recent success of Russia in securing a Pacific harbor on the coast of China, accompanied as it has been by the building of a railroad across Siberia, has enabled Russia to become a commercial nation of great importance. Oceanic routes of commerce, between good harbors, are very largely determined in their direction by the favorable or unfavorable character of the ocean currents and of the winds, and in some cases by the presence or absence of floating icebergs. The influence of ocean currents and winds is interestingly shown by the fact that sailing-vessels from Great Britain to Australia go out by way of Good Hope and return around South America and Cape Horn. This route follows the direction and the course of the southern westerly winds, so that the vessels have favorable winds nearly all the way around the world.

While trade depends very largely upon favorable geographical conditions, there are other aids to commerce, largely the result of inventions, which are of importance. The establishment of beacons and, later, of government

lighthouses on the prominent points of a coast, marking the entrances to harbors or the presence of a dangerous coast, very naturally followed the beginnings of trade. We can see an interesting relic of the former burning of a beacon to guide vessels in "Beacon Hill" in Boston, on which is situated the Massachusetts State House. This hill, in the centre of the city, was formerly the site of one of the early beacons of the Atlantic coast, that shed its light over the tops of the houses that formed the town of Boston, and out over the waters of the bay toward the sea.

Associated with the development of lighthouses, which are located in their position because of the geographic features that make the coast safe or unsafe, we have the modern establishment of government life-saving stations. These stations are located along the dangerous portions of our coast and the parts passed by the greatest number of vessels, the object of the life-saving crews being, of course, to render aid to any vessel in distress. Telegraphs, telephones, the postal system, and express companies are other aids of commerce that have all developed as commerce has developed, and that make it possible for men to take advantage more promptly of the natural conditions about them.

Power.—The success of a people or a nation in taking advantage of the conditions around them depends very largely also upon their opportunity and ability to make use of other power than that of their own hands in doing work. As a result of the desire on the part of all men to save themselves labor, we find the increased use of animals to carry burdens, or to assist in the transportation of goods across country. The Indian warrior, who must ever be on the watch for the game that will give

him food, keeps himself, as a rule, perfectly free to pursue his game at all times, and leaves the moving of the home, the gathering of the wood and the water, and other duties of a similar sort to the women of the tribe.

Among the beasts of burden that are most used are the horse, the mule, the ox, the camel, and the llama. The horse is regarded as a necessary means of transportation by almost all inhabitants of the temperate and semi-tropical regions, and is used very generally for agricultural purposes by the progressive farmers of the leading nations. Where speed is not an essential quality, we frequently find the mule; for instance, this animal is used for drawing canal-boats, which cannot be moved much above a certain rate per hour. In some places, where great strength is required, we find the still more slow-moving ox; but his use is now rapidly declining on farms, because a successful farmer must move more rapidly than oxen can go. At present the special field for oxen in this country is, perhaps, in lumbering camps, where their ability to get through snow and to move heavy loads is of particular value.

In the camel of the eastern deserts we have an animal particularly serviceable for the transportation of men and of burdens across the arid wastes where water can be secured only at long intervals. The supply of water which he carries lasts him many days; his soft-cushioned feet enable him to travel with ease over the hot sand. He is so well adapted to meet the conditions of the desert, and carries such heavy burdens, that he has rightly received the name of the "ship of the desert." The llama of South America, though smaller, performs a similar service for the travellers in the rugged highlands of that region.

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With the development of machinery, there came the desire for power that would set machinery in motion. In certain regions we find horses used in treadmills to turn machinery; this is well illustrated in the threshing of grain, the cutting up of hay and of corn-stalks, and the sawing of wood, as it is carried on on many eastern farms. It is more common, however, to find a more powerful agent employed, agents which are not animate and do not tire. The most natural of these inanimate sources of power is that of falling water, which is still employed, as we have already seen, in many of the cotton mills of the country. Windmills, which are used for the pumping of water, are frequently employed also for running farm machinery; but the supply of power in the case of the wind is so irregular that wind power is somewhat unsatisfactory. Steam power and water power are so superior that the old-fashioned windmills once extensively employed in New England for the grinding of corn are no longer used, and have practically disappeared.

The greatest of all sources of power thus far used is steam, formed, of course, by the heating of water through the burning of some fuel like wood or coal. The possibilities of the use of steam at low cost depend almost entirely upon the ease with which fuel may be obtained. Most of the great factories of the world, and, indeed, the larger number of the smaller industries and most of the railway trains, are moved by steam power. The newest of the forms of power is that of electricity. This is usually secured through steam, so that in most cases electricity is but another way of applying energy acquired from the burning of some product. The advantage of electricity is that its power can be transported long distances from the source of supply without serious loss,

as we see illustrated in the electric car lines that now cover the many large cities, the power usually being supplied from one central source. A power house has recently been established at Niagara Falls, New York, which produces a tremendous quantity of electrical energy from the falling of the water diverted from the falls. This is already so successful that electric power is supplied at moderate cost to the city of Buffalo, twenty miles away. The introduction of electricity for the running of canal-boats and railway trains, as well as street railways, means that very soon not only manufacturing, and transportation of people, but an increasing amount of the commerce of the world, will depend upon the right use of this power. It should be noted, also, that electricity is coming into increasing use as a source of light for houses, railway tunnels, and mines, and as a source of heat for warming buildings and cars, and, indeed, for cooking purposes.

CHAPTER XXIV.

SUMMARY.

SUCH are some of the conditions other than those of climate and topography that determine whether a country will be progressive or not. It should be remembered, however, as we have already suggested, that not every country in the world with good climate, favorable topography, plenty of water, abundant natural products, possibilities for commerce, and ready access to power is a leading nation. Geographic conditions which we have mentioned may be present, and yet a people may make less progress in spite of its opportunities than other people lacking some of these opportunities. Races of men, in order to take advantage of the conditions about them, must be mentally and physically able to make good use of that which is presented to them.

The Chinese nation, situated practically amid the same conditions that the United States enjoys, is among the most unprogressive nations of the world; it should be noted, however, that China has been far removed from its most progressive neighbors, owing to the great land barrier to the west of her and the water barrier to the east. Primitive peoples are much more dependent upon the geographic conditions about them than are advanced peoples, but in each case there is a struggle to take advantage of the favorable conditions and to overcome the unfavorable. The forms of shelter, the kinds of food, the character of the clothing, the implements of the household

and the chase, vary according to different conditions under which people live; but in all cases they are used for the same general purposes. No individual and no nation, however, has so thoroughly mastered unfavorable natural conditions as to be free from all inconvenience because of them. This is well shown, in our temperate regions, by our constant anxiety about the weather in planning for many kinds of enterprises.

The Historical Distribution of Peoples.—We have already seen how man is influenced by the geographical conditions about him. Let us look for a moment at some of the great nations of the world, and see how they have been influenced by these same conditions. In the early history of the world those peoples became of the greatest power who early found their home amid the most favorable conditions, and who gradually developed the ability to go out into new regions and to conquer them. The great civilizations of the Chinese, the Hindus, the Persians, the Egyptians, the Greeks, and the Romans were developed amid conditions that were, on the whole, favorable. The successful ones of these nations have been those who went forth into new countries after the possibilities of their own had been exhausted. This did not take place, however, until they had developed their home region.

As we look back on the history of the development of civilization, we find that we may divide the history of the world into three periods, according to the geographic conditions amid which the successful nations lived at different times. These three divisions are the earlier nations, which developed in the rich alluvial plain of some great river; the later nations, that learned the ways of commerce, because of their favorable situation for such

commerce about the Mediterranean Sea; and, finally, those who have become able to cross the oceans more easily than the land and to whom the whole world, except certain parts that are ice-bound, is practically free.

The Chinese, who developed in the rich and fertile plains of the great Chinese rivers; the Hindus, who grew to great power amid similar conditions about the Ganges; the Persians, in the valley of the Euphrates; and the Egyptians, in the eastern portions of the Sahara, watered by the Nile, are excellent examples of the former great nations of the world, who developed in the alluvial plains of rivers. Later we find the powerful nations of Greece and Rome, their advantage lying in the fact that they were situated on the northern and temperate shores of the Mediterranean Sea, along an irregular coast, which made coastwise commerce possible. Owing to the abundant harbors offered by this irregular coast, the fleets of these nations were given a much-needed protection in time of storms; for the early vessels of these people were either manned by men, or if propelled by sails could only sail before the wind, and not against it. The presence of great numbers of harbors was, therefore, a very valuable physical feature for these people. After their success in combating the winds and the waves of the Mediterranean, the people of this region, like the Norse, who developed amid similar surroundings on the irregular coast of Norway, were enabled to attempt the crossing of the broad oceans.

As a result, we have the discovery of the Western Hemisphere, followed naturally by the rapid development of world-wide commerce. The early nations of the world were, then, river or alluvial plain nations, and mainly agricultural; the later nations were Mediterranean, and

among them commerce was developed. Now the great oceans are no longer barriers, and we are living in an age that may be called oceanic, all the powerful nations, like the United States, England, and Germany, having ready access to the great oceans, and making free use of them in commerce and travel.

The influence of geography, then, can be seen as clearly in the study of the history of a great nation as in that of a city or town. Great numbers of people are collectively influenced by their geographic surroundings in the same way as a few people are. Each individual in a town may also be directly influenced by the geography about him. Thus geography is important to the many as well as to the few, and a study of the world peoples must be accompanied by a study of world geography.

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